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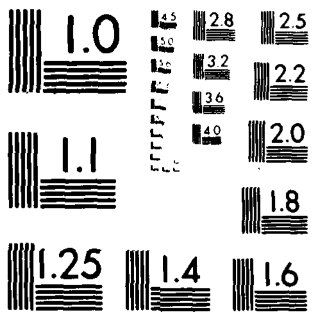

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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EUROPEAN SCIENTIFIC NOTES
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edited by Wayne V. Burt and Don J. Peters

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ELECTRONICS

ELECTRONICUM DUISBURGIS—GAUDEAMUS IGITUR

Germany's rise in the 50s and 60s to become one of the world's great industrial powers has also made it one of the most prosperous. Along with this prosperity has come an expansion of institutions of higher learning and the founding of new universities. One of the latest of these is the University of Duisburg, which in the manner of the legendary phoenix, has risen from ashes of an institution that existed several hundred years ago.

Duisburg, an industrial city of more than half a million people, lies at the junction of the Rhine and Ruhr rivers in the most heavily industrialized region of FRG. It had a university as long ago as 1655; but that institution was closed, after a brief 163 years of operation, in 1818. For more than 150 years the city was without a university. A first step to its resurrection was made in 1972, when a school that trained technicians was stepped up in grade to become Gesamthochschule Duisburg—a school that offered higher, university-type education along with the technician training. In 1979, after the school had expanded to 11 faculties including a *faculty of liberal arts*, Duisburg had a university once more.

Among the 11 faculties, 3 are in engineering. The university proves true to its mixed heritage by offering both a university program, which generally requires around 5 years of study, and a 3-year program for high-level technicians.

At Duisburg I visited the Fachbereich Elektrotechnik, i.e., the Faculty of Electrical Engineering (EE), where my hosts were Prof. Dr. rer. nat. Heime, who holds the chair for semiconductor techniques and technology (also known as the solid state electronics department), and his principal assistant, Dr. rer. nat. L.M.F. Kaufmann. At the time of my visit Heime was also dean of electrical engineering, an elected office which is rotated among the various professors.

EE now has 26 professors and 41 scientific co-workers, many of whom are also candidates for the doctor's degree. There are approximately 550 students, all undergraduates. Graduate students, as we know them, do not exist, since candidates for the doctorate do not take courses or pass examinations except for the final one that covers the thesis work.

As would be expected for a new institution, the scientific co-workers do not yet fill all of the available slots. It is expected, however, that the number of of co-workers will be increased from 41 to 85 in the very near future.

Although the University of Duisburg is new, it is far more than just a teaching institution. There is also a strong emphasis on research. It became quite evident to me that one of the features used to attract new professors is the considerable funding provided for research equipment and the promise of funding for research as well. In the case of Heime, whose specialty is gallium arsenide (GaAs) semiconductor technology and devices, the government of the state of North Rhine-Westphalia, in which Duisburg is located, has provided him DM1.1 million (equivalent to approximately $600,000) for equipment. After 4 years at Duisburg, Heime has a staff of 12. Funding for his department's research comes from four sources: the university, the Deutsche Forschungsgemeinschaft (German Research Society), the Bundesministerium für Forschung & Technologie (the Ministry for Research and Technology), and the Siemens Corporation. Kaufmann mentioned to me that other principal sources for research funding in FRG are the Fraunhoferstiftung (freely translated: Fraunhofer Foundation) and the Stiftung Volkswagenwerk (Volkswagen Foundation).

Heime, who received his doctorate at the Technical University of Darmstadt, has worked on GaAs technology and devices for a number of years. Prior to moving to Duisburg he held a rank equivalent to that of associate professor in the group of Prof. H. Beneking at the Technical University in Aachen. His principal assistant and co-worker for a number of years, Kaufmann, received his doctorate in that group, where they worked jointly on improving GaAs devices used for microwave amplification or high-speed logic devices by controlling the properties of the epitaxial layer in the epilayer-substrate interface. They also developed a novel turnable sliding boat which allows the use of as many melts as are necessary for making a multilayer semiconductor structure in liquid phase epitaxy (LPE) and the production of LPE gallium arsenide GaAs of 4½ cm² dimensions. Heime told me that his group is continuing work on GaAs microwave field effect transistors, as well as on IMPATT devices for operation above 100 GHz, mask technology, and material characterization by such techniques as secondary ion mass spectroscopy (SIMS), and high-energy electron diffraction (RHEED).

Although Heime's group is in temporary quarters, the laboratory setup is quite respectable. There are 5 technological and 3 measurement laboratories containing, among other items, 2 impressive looking GaAs LPE facilities along with appropriate vacuum systems, photolithography

equipment and related apparatus, computers, and microwave measurement equipment. I noticed that careful attention is also paid to laboratory safety, something I have not always seen in my visits to other laboratories. For example, hydrogen sniffers were installed and were programmed to shut down operations in case of a leak. Kaufmann made a special point to emphasize also the importance of protecting his LPE systems from contamination by external sources and claimed, in fact, that some of the recent successes of the group were due to special attention in constructing the systems.

It has taken a couple of years to order, install, and put into successful operation the rather complex equipment required for carrying out this GaAs work, but the laboratory is now in operation. In recent publications, for example, the group has disclosed that it fabricated GaAs microwave field-effect transistors with excellent I-V characteristics by diffusion from doped-oxide into chromium-doped substrates. A recent article discusses the measurement of trap density in space-charge regions adjacent to the conduction channel of a GaAs MESFET by what the group calls the photo-f.e.t. method—a new technique. (See *Electronics Letters*, Vol. 16, 3 Jan 1980; pp. 22-23.)

Heime's institute is, of course, not the only one at Duisburg that has initiated research activities. An annual report for 1979 lists 38 research publications by the Electrical Engineering Department during the first 10 months of that year. These papers range from microwave networks through communication theory and power distribution to the rather interesting subject of measurement of content and particle size distribution of various aerosols.

In view of what I saw of the research activities, it is reasonable to conclude that if research funding continues, the new University of Duisburg will continue to expand its contributions to technology. (Irving Kaufman)

ENGINEERING

ANTENNA RESEARCH AT CHALMERS UNIVERSITY IN GOTHENBURG

Chalmers University of Technology (Chalmers Tekniska Högskola) is located in Gothenburg on Sweden's west coast. It was founded in 1829 and recently celebrated its 150th anniversary. Chalmers is a state institute catering to about 4,000 government-supported undergraduates and 500 graduate students. A further 1,000 students take single courses. The Electrical Engineering (EE) Department of the university has about 800 undergraduates. The master's degree takes nominally 4½ years to earn and postgraduates usually take a further 5 to 6 years for a PhD or DSc degree. Research is mostly supported by government or industrial grants. Chalmers employs a total of about 2,000 people including supporting staff, full-time, and 1,000 more, such as guest lecturers, on a temporary basis.

The budget of the university, which almost entirely dependent on government support, amounted to the equivalent of $60 million for the academic year 1979/80.

Separate from this technical university is the Gothenburg University with some 25,000 students registered in the humanities, the sciences, medicine, and dentistry. This makes Gothenburg very much a university town.

Prof. E. Folke Bolinder, the director of the Department of Network Theory in the School of Electrical Engineering at Chalmers, is very active in antenna research. This was the reason for my visit to him. Bolinder's interest in antennas dates back many years to the time when he worked in this field at what was then the Air Force Cambridge Research Center in Cambridge, MA. He has achieved prominence and was recently invited to China where he gave talks on phased array technology.

The research staff numbers 12 people, including 7 teaching assistants paid directly by the government and 2 teaching assistants funded by the Swedish Board of Technical Development (Stockholm). Teaching assistants usually are graduates studying for a higher degree and can be employed by the university for a maximum of 6 years. Other staff members virtually have tenure; they can be transferred but cannot be terminated.

The money for research, which comes mainly from the government, pays for salaries and equipment. There is much interschool competition for available funds and trading people for equipment is a possible gambit. Bolinder believes that it is important for his postgraduate students to spend a year in the US after completion of their studies. This he can usually arrange by means of a scholarship from the Sweden-America Foundation.

Bolinder and Dr. Peter Starsky of the research staff described some of the research. There have been several phased-array research and development projects. One such project was CHALMANT (CHAlmers L-band Maritime ANTenna) intended for a ship-borne communication-via-satellite system. The requirement, set by the European Space Agency (ESA), was for a minimum gain of 20 dB and the choices available

were mechanical steering, electronic steering, and switched multiple antennas. The most cost-effective method was found to be a combination of all three. The antenna system consisted of 2 antenna panels, each having 64 elements, connected through cables and PIN-diode switches which joined the elements of one or the other of the panels to phase-shifters and a strip-line (20 dB Chebyshev) combining network. Each panel could be scanned ±35° electronically and rotated mechanically in azimuth. The radiating elements were cavity-backed circular slots fed from 2 orthogonal probes in phase quadrature, giving right- or left-hand circular polarization. The elements were spaced in a square matrix. The match was good enough without having to resort to special matching techniques, and the overall measured antenna gain was found to be about 20 dB at broadside and about 19 dB when scanned to ±35°. The match and mutual coupling were investigated in detail by Anders G. Derneryd. An electronic conical scan system was used for acquisition and tracking. A spherical radome, obtained from the Norwegian firm Norcem Plastic, was found to operate satisfactorily. The system was mounted on a mine sweeper and given a prolonged sea test during summer 1979. It was a most successful test which showed that continuous operation not only was possible, but actually gave a considerable amount of excess signal.

Many of Bolinder's antenna projects have code names starting with CHA to signify Chalmers University. CHALME (CHAlmers and L.M. Ericsson) indicates cooperation with the L.M. Ericsson Telephone Company that has a military-application-oriented facility in Gothenburg with considerable interest in microwave antennas. It was a 9-element X-band phased-array with phase shifters and a power dividing network that gave a tapered (low side lobe) amplitude distribution. CHALPHAS (CHALmers PHased Array System) is an X-band 64-element system using dumbell slots as radiating elements. The slots are coupled by strip-line from below. The system was found difficult to build and assemble. The phase-shifters use ferrite meander-lines. CHALAPRA (CHALmers Automatic Picture Receiving Antenna) is a 10-element, 135 MHz phased-array for receiving from a satellite. It has 3-bit phase shifters and the radiating elements are crossed dipoles. The antenna is electronically scanned to follow the satellite.

Other developments include well-matched strip-line power dividers with various coupling ratios and wide-band well-matched strip-line 90° bends. Microstrip printed antennas were investigated. Matching with strip-line inputs (rather than by coax from below) was found to be difficult but a narrow-band configuration was found for square patches. Ferrite circulators were developed at C-and L-band with ferrite materials obtained from the US and from the Swedish Defence Research Establishment (FOA) in Linköping.

New work under way includes the fabrication of an L-band conformal phased-array. Sixteen elements are connected through phase shifters and attenuators, both of which are adjusted electronically. The elements are in the form of strip-line patches and use linear polarization. They are on an 0.9 m diameter cylinder. Another project about to start is a study of a wide-angle microwave line source lens system (probably a "Rothman Bootlace Lens" configuration).

An anechoic chamber is available using Plessey absorber. It was discovered (most fortunately) that the university Works Department is tasked to look after all forms of wall coverings, normally wallpaper or paint. In this instance, however, they were asked to procure and install the very costly microwave absorber "to cover the walls". They took it in their stride and performed the work without charge to the EE Department.

Gothenburg is probably the main center in Sweden for work on microwave antennas, with Bolinder at the university and the L.M. Ericsson Telephone Company, which has a very active antenna group, in nearby Mölndal. There is much cooperation between them. (T.C. Cheston)

HOLLANDSE SIGNAALAPPARATEN B.V.

During a visit to Holland late in 1979, it was my good fortune to visit the Hollandse Signaalapparaten B.V. (HSA) in Hengelo. It is an impressive Phillips-owned company involved in defense electronics, and producing radar, sonar, weapon-control, data handling, traffic-control, space and other systems. The company was established by Phillips in 1922. In 1946, just after WWII, the Dutch Government took it over and then gradually, over a number of years, released it back to Phillips, which now again owns it completely. It is one of several production facilities forming the international group, "Telecommunication and Defence Systems," with locations in Western Europe stretching from France to Sweden.

At Hengelo I saw little of the international aspects of the company. It seemed very Dutch to me. It was said that the HSA staff of about 4,500 felt clannish, like a family with close ties to each other and the company, and that it took a long time before a newcomer was accepted. A

main building is backed by beautiful, large, glass windows, etched in a most artistic way with figures and designs. This, I was told, was a gift from the employees to the company (!).

The company was known through its "Broomstick" radar that had been developed there. That radar is now obsolete but in its time it was an advanced, rotating, high-data-rate, ship-borne system for both search and track. At this time many different systems are being produced, and I was impressed by the overall high level of engineering. About 60% of the company's business is for the Navy, 20% for the Army and about 10% each for the Air Force and for civilian use. Sensors have been developed including radar, sonar, and optical systems. The company's radar systems cover the spectrum from millimeter wavelengths to the decimeter wavelengths of L-Band and give local search, track or fire control with low power; or long-range surveillance with high power, pulse compression, and MTI (Moving Target Indication). Further, an active, medium-range sonar system is available for underwater search and track, and optical, infrared, and television systems are produced for both search and track to supplement the radars.

The information from the sensors is processed by special data-handling equipment and is displayed graphically or with a variety of display consoles.

The sensors, processing equipment, and displays are integrated with guns or guided-weapon systems in many different combinations to give completely autonomous local control. Still further integration with other systems is possible, giving complete combat control systems of varying complexity.

I saw one particular integrated system, the "Flycatcher," in various stages of assembly. It is an all-weather weapon-control system for guns and guided weapons, and operates autonomously. Separate search and tracking radars are mounted on a common trainable pedestal that also holds a TV system which offers the operator a visual image of the target that is being tracked with a track-while-scan circuit. Another system, "Seawolf/VM40" is the result of a joint design effort of HSA and the British Aerospace Corporation. It is a light antimissile defense system for ships with displacements of 800 tons or more. Two missiles can be guided simultaneously. Complete blind-fire capabilities are claimed, even against small targets in heavy clutter, including wave-skimmers. A TV camera is also integrated with this system.

A bi-monthly newsletter, *Signaalflash*, is published describing new developments. Free subscriptions may be obtained by writing to HSA at P.O. Box 42, 7550 GD Hengelo, Holland. (T.C. Cheston)

MICROWAVES AND SEMICONDUCTORS AT THE ROYAL INSTITUTE OF TECHNOLOGY AND THE INSTITUTE OF TECHNOLOGY, STOCKHOLM

Sweden has a population of 8 million, with virtually zero population growth. About 1.3 million people live in metropolitan Stockholm, a truly outstanding city. It has a fascinating "old town", a fantastic new shopping area as modern and grandiose as can be found anywhere, and an archipelago of 24,000 islands right outside the city, with ships and sailboats dotting the blue waters between them. The Swedish nation has enjoyed uninterrupted peace for about 170 years. Consequently, there have not been any catastrophic events to change the face of the city during that period. However, continuous change and modernization appear to have been the motto (except for that part of the city kept on purpose as the "old town"). As an example, the Royal Institute of Technology (Kunglgia Tekniska Högskolan, KTH), now 152 years old, has its Electrical Engineering Department (EE) in a structure dating back to the early *1900s*. Yet this building looks quite new and contains up-to-date facilities. It has also a history of good research. H. Alfven, 1970 Nobel laureate in physics, was a professor at KTH associated with EE until his retirement.

KTH has somewhat over 5,000 students. According to our host, Dr. Peter Weissglas, who is both a professor in EE at UTH as well as the Managing Director of the Institute of Microwave Technology (IM), EE undergraduate education is, on the average, a 5-year program that leads to the title Civ. Ing. There is no tuition fee for students, and in fact, students receive a subsidy from the government to aid in meeting cost-of-living expenses. This means that there is a selection process that limits university enrollment. It also means that there are few foreign students. In the past few years the majority of the 200 EE students who graduate each year have found employment with Ericsson, the large Swedish manufacturer of telecommunication equipment and systems.

As in a number of other countries on the Continent, the one graduate degree is the doctor's degree, obtained without formal course work upon acceptance of the thesis after an average of five years of research. EE awards five to ten doctor's

degrees per year. Financial support for graduate students varies from a mere subsistence level to the regular salary of a full-time employee.

There are several active areas in EE. While we only had the opportunity to learn about work in microwaves and semiconductors, we heard also of interesting work in speech communications and the acoustics of music, as well as in telecommunications and networks and systems theory.

Microwaves were being used in cancer therapy research projects conducted by the EE Department in cooperation with a hospital in Lund. The first clinical experiments with patients, using a matched circular wave guide and circular polarization, were just about to start. Weissglas pointed out that this was probably an effective and relatively harmless method by means of which maximum heating was achieved at the center of a tumor which was less well cooled by blood than its periphery. Some other studies, which are still in a very initial stage, are directed at the formation of microwave images using multiple frequencies and aimed at industrial control such as position location and automatic handling.

IM was founded as a legally independent entity in 1968 to support Swedish industry. Its "owner" is essentially the Swedish government, represented by an agency called the Swedish Board for Technical Development (SBTD). All of IM's work is performed on a contractual basis. Although IM remains very active in microwave work (its original mission), it has also become heavily engaged in solid-state device work. Here it follows the pattern set by the government of aiming towards developing new industrial products for export. Figures show that the industrial output of Sweden has decreased, and government planning boards are now hoping to reverse this trend with electronic products. (At present, electronics accounts for only 5% of Swedish industry; much larger sectors are the ones devoted to the production of machinery, and the paper industry.)

Within the electronics sector, two companies were mentioned by Weissglas as being the principal semiconductor device manufacturers of Sweden. They are RIFA, a subsidiary of Ericsson, which manufactures passive and active components, custom-design integrated circuits (ICs) and hybrid circuits, and which now is expanding rapidly into ICs using NMOS (N-channel metal-oxide-semiconductor) and CMOS (complementary metal-oxide-semiconductor); and ASEA-HAF, a subsidiary of ASEA (the large manufacturer of electric power equipment), whose products are CMOS, silicon on sapphire components, and electro-optic devices. There is also a division of ASEA that manufactures solid-state power devices.

IM has been expanding very rapidly. Weissglas told us that his annual budget has increased from Skr 4.5 million five years ago to Skr 13 million this year and that it is planned to reach Skr 20 million next year. (The equivalent approximate dollar figures may be found by dividing by four.) There are presently around 70 workers in IM including 25 PhDs, and Weissglas, as managing director, spends about 95% of his time there. Funding is from SBTD and industry as well as from the exploitation and sale of patents.

The solid-state work at IM falls into the three areas of electro-optics, ICs, and solar cells. Phase I of the electro-optic work was to develop the technology required for producing quartz fibers and GaAlAs lasers. Multimode fibers with a radially varying index of refraction have indeed been made satisfactorily. The technique, which is well known, starts with a glass tube about 1/2 inch in diameter, whose inside surface is chemically modified by a vapor. The tube is then heated, collapses, and is then drawn to form a thin fiber. Fibers whose attenuation is approximately 4.5 dB/km or better have been manufactured, and the technology has been transferred to industry. As for the lasers: these have also been developed, except that there is still a yield problem in the fabrication.

The task of Phase II of the Electro-Optics Group, which was in progress during our visit, is to fabricate single mode glass fibers and InGaAlP lasers and detectors (for the 1.4 μm region). Weissglas stated "I expect to see 1.4 μm light before summer." (June 1980—He was referring to invisible light, of course.) The optical source and detector work is under the direction of M. Janson, who told us that the effort so far has concentrated on the growth of the quaternary laser structure by liquid phase epitaxial (LPE) techniques. In Janson's words, "Vapor phase epitaxy techniques may ultimately be more suited for production than LPE but require more complicated equipment." He viewed as problems yet to be solved the stability of the optical pattern in the laser with time, elimination of self-oscillations, and modulation distortion. Janson's first lasers will be of the usual stripe configuration (for purer pattern and lower threshold current) with stripe definition by proton implantation.

Until recently there were only eight people in the Microelectronics Group, five of whom were engaged in electron-beam lithography (EBL) work. During the last few months IM has added 13 professionals (7 with doctorates) and 9 technicians to this group. Dr. K. Björkqvist, who is responsible for microelectronics work,

stated that the present aims of the group are to concentrate on silicon MOS devices, ICs on GaAs, and EBL for very large scale integration (VLSI); to build up a design center in microelectronics (to develop extensive software); and to refine the technique of measuring voltages in ICs on internal nodes with a scanning electron beam.

The studies of MOS device behavior have entailed an examination of threshold and subthreshold currents for devices possessing channel widths from 0.5 μm to 10 μm. In this work IM has combined efforts with the Applied Electronics Department of EE. To fabricate devices, the group has made use of a 250 keV Dan-Fysik ion implanter. The GaAs IC project, just recently started, is to develop a good channel-doping technique and to work principally with J-FET logic arrays.

Björkqvist felt that in EBL work IM had developed a scanning electron microscope (SEM) for direct writing on wafers that is at least as good as that of Cambridge Instruments. The cathode in the IM system is a heated field emitter; the electron beam can be smaller than 0.2 μm in diameter. Technology for this SEM has now been transferred to the Scanditronics Company of Uppsala, Sweden, which expects to market the instrument.

It may seem surprising that Sweden, so far in the north, has efforts in solar energy utilization. Weissglas mentioned however, that the insolation in Sweden during seven months of the year is almost as much as the best in the US and that Stockholm has the same amount of annual insolation as Paris. Actually Sweden has a fairly ambitious energy program involving nuclear energy, biomass, wind, solar heating, and a smaller program in photovoltaics. Biomass and wind seem to be getting the emphasis within the research area. IM is the only group performing R&D work in Sweden on photovoltaics. The technique being developed at IM uses the well-known method of amorphous silicon glow discharge deposition originated by Prof. W. Spear of the University of Dundee, Scotland.

There were many other developments in microwave systems. For example, a microwave receiver design was being studied that was relatively cheap and could be added to a TV set to receive signals directly from satellites covering Scandinavia. Dr. Florian Sellberg, head of the Semiconductor and Electronics Division, described this work, which was carried out in conjunction with Norwegian and Finnish efforts, aimed at bringing TV to the more remote parts of those countries. The transmission is X-band and is received on the ground by a 90 cm parabolic reflector antenna (approx. 39 dB gain). Field tests, without satellite, are expected to start in 1981.

Weissglas described microwave-labeling identification systems. Various forms have been studied over the last ten years. In one system, railroad freight cars are being identified. This is most useful in goods yards, for example, where without good bookkeeping it is quite easy to lose track of one's assets. Other applications, currently being manufactured and sold in quantity, are directed to the control of cattle for feeding, surveillance, milking, and selection. Further areas where these labeling selectors are useful are automobile assembly lines and bottleneck situations such as the Lincoln Tunnel in New York, where the aim is to achieve an automatic billing system for the tunnels and bridges of the New York area.

Dr. Anders Sjölund of the Measuring Instruments and Systems Division described a most effective ship's log. The system is quite simple and exceedingly effective and measures the relative speed of water at a selectable distance below the ship. In this way, eddies that exist in the vicinity of the hull can be avoided and better measurements can be obtained. The technique involves the use of a high-frequency (150 KHz) sonar that transmits a train of pulses directed substantially downward from the ship in a beam (about 20° wide). Echoes from particles and air bubbles in the water are received and filtered by a range gate for a chosen depth, for example, 30 feet. A second similar sonar is installed in very close proximity to the first, about 1 inch fore or aft of it. The received outputs of the 2 sonars are similar and vary with time as a function of the change in the echoing particles that are present, but the output of the aft system lags in time corresponding to the travel time of 1 inch (50 msec for 1 knot). This time delay is found by correlating (multiplying) the 2 signals after applying variable artificial time delay to the first one, and hence the ship's speed is calculated. Source errors are due to currents induced in the water by the ship's passage and amount to less than 1 knot; they can be significantly reduced by calibration. In shallow waters (less than 200 m) reflections from the bottom can be used; this gives a more precise speed indication, and one that is relative to the earth, rather than to the water. Under those circumstances accuracies of ±0.1 knots are claimed for speeds of -8 to +40 knots and depth measurements (0-240m) also become available. The system is being marketed by Junguer Marin AB, Fack, S17120 SOLNA, Sweden, under the name SAL ACCOR. An improved system at a higher frequency and with narrower beam width (2°) is presently being worked on. Other imple-

mentations of the same principle of remote measurements are used to ascertain the velocity of a ribbon of hot (or cold) drawn steel or the velocity of a train over its rail. Still other methods use electrostatic charge variations as correlation inputs to measure the velocity of yarns or cloth. Other devices yet use LEDs for speedometers to measure, for example, the flow of suspended pulp in papermaking. The technique appears applicable to a wide range of industrial needs.

Microwaves were used in a different application to measure the level in vertical coal chutes in mines. This was done by transmitting across the chute at various levels and noting the change in the reflection coefficient as the chute filled up.

Dr. B. Bergren, in charge of the Microwave Heating Division, and Mr. Yngve Hässler discussed some of their programs. A major project they are working on now is the use of microwaves to retread tires. The radiation system is in the form of four small alumina-filled radiators. Heat has to be developed in the right places, and this is done by using a high-loss glue and a low-loss tread. It takes about 15 minutes to apply a new tread. Other research of the group is directed at an examination of glass and resin materials for use with microwaves. Carbon is being added to increase the losses and to generate heat. A method has been found to produce polyester glass tubes for ski poles on a continuous basis. The plastic hardens as the tube passes continuously through a microwave oven. Injection molding of plastic looks like another possible area of application. Further applications of microwaves that are being studied include the melting or softening of glass, the use of high energy in mining to crumble rocks, and the measurement of the impedance of rocks as a way of differentiating between types. A recently successful application involved fixing the tops of milk cartons using fast-melting wax as adhesive.

The impression left by this visit to IM was that although IM is strongly connected with the university, it performs functions generally carried out by development laboratories of large companies in the US. IM appears to be performing this function well and to be following it up with subsequent effective information transfer to industry. Perhaps the most impressive aspect is the wide variety of problems that are being tackled. (Irving Kaufman & T.C. Cheston)

MATERIALS SCIENCE

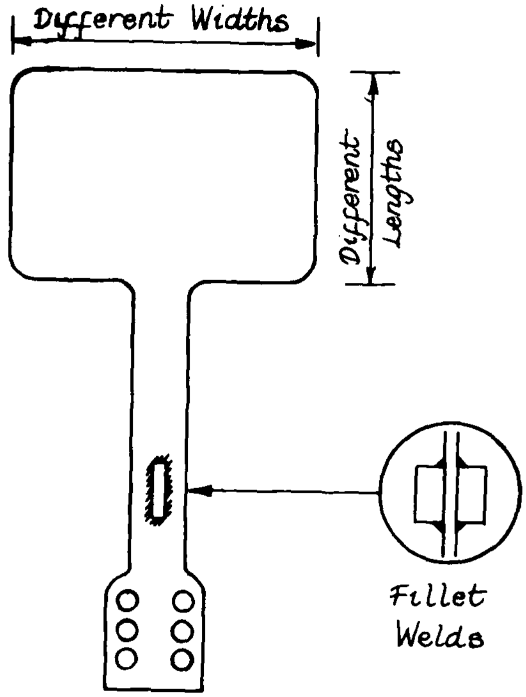
THE BP RESEARCH CENTRE

Sunbury-on-Thames sounds like a small village basking in the sun and clinging to the banks of the River Thames. Unhappily, there is not all that much sun in Sunbury (or anywhere in the UK for that matter) and what may have been a small village at one time has been engulfed by the urban sprawl known as Greater London. Contained within the township of Sunbury is the Research Centre of the British Petroleum Company Ltd. The bulk of the research is carried out within the New Technologies Division (NTD) of the centre.

NTD is divided into the following branches: (1) Biological Science (operational problems and corrosion by fouling organisms); (2) Chemical Science, which is currently being reorganized to emphasize synthetic-organic chemistry and operational catalytic processes; (3) Physical Science, where the emphasis is on secondary oil recovery, coal/oil dispersion, and electrochemical technology; (4) Materials Science, which includes work on coatings, advanced polymers, composites, corrosion fatigue, and catalysis; and (5) Special Projects, where promising research results are scaled up and brought to market. Out of this diversity of activity I would like to describe two projects: a program on the design of welded joints for offshore structures, and the development of coal/oil dispersions.

In 1970 the UK Department of Industry (DI) began a program on the design of welded joints for offshore structures. Up to that time welded joint design codes were based on codes used for building bridges. BP was critical of the DI program, since it allowed for only random loading, no laboratory tests were planned to correlate with field (North Sea) results, and no account was taken of stress relieving or marine fouling. Consequently, Dr. P.G. Faulkner in the Materials Science Branch of NTD organized a program that would include both field and laboratory tests, the effects of marine biological environment, and known loads on the field-test specimens. This project is now underway with funding from BP, British Gas, the British National Oil Corporation, and the DI.

Field test specimens have a paddle shape and an unloaded beam fillet weld near the base. The weld is about 10 meters below the water surface. By varying the paddle size, different loads and load histories are obtained.



The stress data taken near the weld are sent to the Welding Institute (Cambridge, UK) where laboratory specimens are subjected to the same stress levels. These laboratory tests are, of course, not subject to marine biological environments, and Faulkner hopes comparison with field data will give some indication of the effects of marine organisms. The test paddles have been in place for less than two years, but as yet there are insufficient data to form any conclusions. The program is not without its critics who say that offshore tests are too expensive and unwarranted, that the welds should be load-bearing (e.g., a flan flange weld) and that the paddles should be notched near the welds. Faulkner believes that field tests are absolutely essential despite their costs and that data interpretation is already difficult and would be unmanageable if the welds were load-bearing and notches were introduced.

One of the most impressive developments at BP Research has been in coal/oil dispersions. From the turn of the century there have been attempts to extend fuel oil by mixing in finely divided coal particles. Most of these efforts attempted to use surfactants as dispersing agents and sometimes water was included to aid the dispersing action. At best these early dispersions remained suspended for about 24 hours after which the coal had completely settled out.

BP has developed dispersions with very respectable stabilities containing about 30-40 wt% coal (30 per cent oil-volume replacement). Tests showed no separation of the coal after 13 weeks at 100°C which suggests a much longer stability at ambient temperatures since increasing the temperature tends to accelerate the settling process. They have conducted two field tests. The first was at a refinery in a typical marine boiler using a standard burner nozzle. The fuel was stored for six weeks before the test and then used to fire the boiler for one week. There was surprisingly little wear on the nozzle by the abrasive coal particles, but there was serious wear of the fuel pumps. The wear of the pumps may have been accelerated by the fact that the pumping temperature had to be held at 80°C to reduce the viscosity of the suspension; the BP coal/oil dispersion is thixotropic. Ash accumulation was not serious—10% in the fire chamber and a deposit on the heat exchangers. Higher air drafts and a guard plate for the exchanger would reduce these problems.

The second test was conducted on a BP ship at sea. A 1000-gallon tank with its own feed lines fired two burners. The fuel was stored at ambient temperature (25-30°C) for 10 weeks except for a 4-week period when it was inadvertently allowed to heat to 80-100°C. This higher temperature exposure caused some coal to settle out. In the test the coal/oil dispersion performed remarkably well with no ash emissions from the funnel and only loose ash in the burner which could be blown out.

The present cost of the coal/oil dispersion is about even with fuel oil itself; the reduced amount of oil just offsets the cost of coal processing. The BP workers see the dispersion as bridging between the present oil situation and when coal takes over.

As one might expect, the method of dispersing the coal in the oil is proprietary. The BP process can be used with most coals and fuel oils and also can be used to stabilize other coal/liquid dispersions, e.g., coal/methanol suspensions. It seems likely that the secret of BP's success lies in the grinding of the coal or in the media in which it is ground. Basic development probably owes much of its success to the extensive and well-known work at BP on graphite by Dr. A. Groszek.

The materials research effort at Sunbury is at the level one would expect of a major, international oil company. I was especially impressed by the efforts of Dr. J.J. McCarrol, who heads the Materials Science Section, and who is building a surface science group with considerable

capability in the surface spectroscopies which will be applied to fundamental problems and to field problems in corrosion, catalysis, and lubrication. In my conversations with McCarrol he left me with the impression that there is good information transfer between the research people and the rest of the company. Also, he anticipates that the increasing company profits will mean that more research funds will be available during the coming years. (Willard D. Bascom)

MEDICAL PHYSICS

ENDEMIC GOITER—A RESEARCH STUDY IN ZAGREB

The most common diseases of the endocrine glands are those of the thyroid. One estimate places the number of persons suffering worldwide from endemic goiter at some 200 million. In Yugoslavia goiter occurs in Slovenia, Bosnia-Herzogovina and northern Croatia; It is most endemic in the area north of Zagreb. Goiter is also widespread in other parts of Europe including Austria, Switzerland and West Germany. In the case of the last-named region, it is estimated (P. Pfannenstiel, 1975, "Diagnosis of Thyroid Diseases"; Kern and Birner, Frankfurt am Main) that there are more than one million patients with thyroid diseases. Of these about 700,000 have enlarged thyroid glands.

According to Pfannenstiel there are more than 50 different forms of known thyroid diseases. "Iodine deficiency, goiter-inducing substances, endocrine stress and defects in iodine metabolism may alone, or in combination, influence the thyroid hormone production and thus cause a peripheral deficit of thyroid hormones."

Thus it is not surprising that a major activity of the Nuclear Medicine Clinic in a leading hospital in Zagreb (the Dr. Mladen Stojanović Hospital) is the diagnosis and treatment of diseases of the thyroid gland. The director of this clinic is Prof. Dr. S. Spaventi, who is assisted ably by Dr. Zvonko Kusić. Some 50% of the radiopharmaceuticals used are for studies of the thyroid gland (20% are for renal studies, and 30% are for the rest of the body, including the brain and bones). Thirty-five patients are seen daily for thyroid studies. Of the 70 staff persons employed in the Nuclear Medicine Clinic some 20 to 30 are goitrous, but all are now euthyroid (normal) in function.

A widely used diagnostic procedure is the so-called thyroid scan. The patient is administered a radiopharmaceutical, often Technetium (Tc)-99m ($Na^{99m}TcO_4$) as pertechnetate, 2 to 5 mCi per study, given intravenously. A "gamma-ray" camera is capable of registering the 140 keV photons released by the Tc-99m in the thyroid gland, so that an image or picture of the distribution of the radiopharmaceutical taken up by the gland is obtained. Such images are important in guiding the physician to a correct diagnosis, including the question of whether or not thyroid carcinoma is present. Tc-99m has largely replaced I-131 in these scans for a number of reasons. A more favorable half-life (6 hours vs. 8 days), better gamma ray energy for detection, and lack of beta particles in the Tc-99m decay all lead to the production of higher quality images plus much lower absorbed radiation dose for the patient. Other advantages of Tc-99m are its low cost, and its easy availability in the Nuclear Medicine Clinic by means of a Mo-99 generator.

In recent years, a possible competitor to Tc-99m has arisen in the form of I-123, which has a 13 hour half-life, and a relatively simple decay scheme (via K-capture [98% of the time] with the emission of two photons in virtual coincidence: a gamma ray of 159 keV and a characteristic K x-ray of iodine at 28 keV). The value of I-123 as a superior diagnostic agent has been reported in small numbers of patients by some investigators (e.g., Lee WNP, et al., *J. Nucl. Med.* 19:985, 1978). It is considered to be the most desirable radioisotope of iodine for *in vivo* use because of its short half-life, its favorable photon emissions leading to high quality scans and the very low absorbed radiation dose for the patient's thyroid gland.

The present largest drawbacks for I-123 are its relative unavailability and its high cost. This stems from the fact that to make I-123 in a highly purified isotopic form (relatively free of I-124, I-130, and other longer lived radioisotopes of iodine), one must use an accelerator with high energy protons, in excess of 50 meV. Such machines are not available in great numbers. However, it is possible to make I-123 with lesser isotopic purity more easily, and this is being done in the United States by a commercial firm. I-123 with higher isotopic purity is being made at the Crocker Nuclear Laboratory of the University of California at Davis. However, the I-123 made at the Crocker Laboratory is only distributed to specialized research centers, and not to medical practitioners. In the UK, on the other hand, Harwell makes I-123 with higher isotopic purity and the material is available to all who can use it.

As stated previously, Tc-99m has been shown to be an adequate imaging agent. One of its major disadvantage is its relatively low uptake by the thyroid (about 2%), resulting in high background activities. Another objection voiced by a number of thyroidologists is the fact that Tc-99m is not iodine, and therefore, cannot be organified as is the case for iodine. That is to say, concern has been expressed about the different physiological processes by which iodine (trapping by the thyroid followed by organification) and technetium (trapping only) are taken up by the thyroid.

The choice of an appropriate radionuclide depends on many factors: availability, biological half-lives, dosimetry (absorbed dose), and the differential diagnosis being considered. For the last reason Tc-99m is not used for the evaluation of metastatic thyroid carcinoma. In situations where either Tc-99m or I-123 may be used for the evaluation of a thyroid nodule, the uptake of either material is assumed to indicate the same aspect of thyroid iodide metabolism. Unfortunately this assumption is sometimes found to be wrong. Differences in uptake have been reported (O'Connor MK, et al., *J. Nucl. Med.* 18:796, 1977), in which a thyroid nodule classified as a hot nodule by Tc-99m scan may be classified as a cold nodule by a I-123 scan.

For the reasons described above, a cooperative clinical research study is being planned jointly by the group in Zagreb, a team at the UCLA School of Medicine, and the Bureau of Radiological Health, Food and Drug Administration, Rockville, MD. The Zagreb team includes several physicians and physicists at the Nuclear Medicine Clinic (Prof. Dr. Spaventi, Dr Kusić, M. Ivanović, L. Lukinac, V. Lokner) and scientists from the prestigious Rudger Bosković Institute (Prof. Dr. Ivo Slaus, Dr. Z. Bajzer, Dr. S. Kaučić, and Dr. L. Horvath). The UCLA team includes Dr. W. P. Lee, (physician), Dept. of Pediatrics, and Dr. J. Whiting, (physicist), Dept. of Radiological Sciences. The Bureau of Radiological Health is ably represented by Dr. Peter Paras, a physicist, and by an eminent consultant physician, Dr. Eugene Saenger of the University of Cincinnati.

The major thrust of the work in Zagreb will be a comparison of Iodine-123 and Technetium-99m as imaging agents for thyroid studies. The Technetium-99m is available daily from Mo-99 generators. The Iodine-123 in high-purity form will be purchased from Harwell in the UK. The study will be limited to patients with palpable nodules who would normally be scheduled for a thyroid imaging procedure.

The primary purpose of the UCLA study will be to investigate the different biological properties of Tc-99m and I-123 as radionuclides for the study of thyroid iodide metabolism. The aim will be to gain understanding of the problem of "disparate" imaging, and to provide criteria for the choice of the two radioactive agents in clinical thyroid studies.

The Bureau of Radiological Health is providing training for personnel at Zagreb, a detailed protocol, and some funding.

The entire program is an effort to accomplish needed and useful research requiring the combined resources and talents of medical professionals from 3 countries. (Moses A. Greenfield)

MEASUREMENT OF ULTRASONIC EXPOSURE—A VIEW FROM WARSAW

Several years ago I had the pleasure of meeting Dr. Jerzy Zieniuk when we were both Visiting Scientists at the Bureau of Radiological Health, Food and Drug Administration in Rockville, MD. Zieniuk's expertise is in acoustics, and more particularly in the measurement of ultrasound intensity in terms of the factors that influence the interaction of the ultrasonic field and the medium being irradiated. I recently visited him in Warsaw where he is a staff member of the Institute of Fundamental Technological Research (IFTR). The institute in turn is a part of the Polish Academy of Sciences.

The institute is relatively young, having but recently celebrated its 25th anniversary (1977). The two major activities currently are acoustics and theoretical mechanics. The work is structured and is carried out through departments, of which there are thirteen. The roster of departmental names suggests an interest in both theoretical and applied aspects of acoustics and mechanics. They are: (1) Theory of Continuous Media; (2) Mechanics of Continuous Media; (3) Structural Mechanics; (4) Fluid Mechanics; (5) Mechanical Systems; (6) Physical Acoustics; (7) Acoustoelectronics; (8) Ultrasonics; (9) Cybernetic Acoustics; (10) Theory of Electromagnetic Waves; (11) Nondestructive Testing; (12) Aeroacoustics; (13) Energy Problems.

In addition there are 13 sections, basically specialized laboratories, that do not fit into the category of broad departments. In fact some are located elsewhere (e.g., in Poznań). The major sections are: (1) Strain Fields; (2) Polymer Physics; (3) Continuum Electrodynamics; (4) Atomic Frequency Standards;

(5) Geoacoustics; (6) Acoustical Phonetics (in Poznań); (7) Theory of Consolidation and Thermodiffusion (in Poznań).

Altogether, there are about 700 persons in the institute including scientists, staff members, technicians and administrators. The operating budget comes from the Polish Academy of Sciences, and also from contracts between departments and industrial firms that require specific problems to be studied. Among the specialized sections there is one called "Experimental Department TECHPAN," which is a factory where instrumentation or other developments for industry can be "tried out."

Most of the departments are headed by scientists who have the title "Professor Dr." The title "Professor" does not necessarily imply a teaching function or obligation, although many such persons do teach at the University of Warsaw. In Poland, an individual who has earned a doctorate (and after the passage of years and many publications) may apply for a "docent" degree which is based in part on passing an oral examination. After more years have passed, an institute can request the state council to award the professorship (in two steps: ordinary professor and professor) to the individual. The decision to confer or withold this title depends on the person's total record, including publications. The entire affair is a formal and rather bureaucratic procedure. At the IFTR the professors may choose to be researchers only, or if they wish, they can also teach.

The Department of Ultrasonics is directed by Prof. Dr. Leszek Filipczyński. This department is organized into 3 sections, each headed by a senior scientist: Ultrasonic Introscopy (Dr. Jerzy Etienne), Ultrasonic Methods in Biology and Medicine (Dr. Grazyna Lypacewicz), and Ultrasonic Holography (Dr. Jerzy Zieniuk).

The research work of the Department of Ultrasonics is concerned with basic and applied problems of physics and ultrasonic technology. A considerable effort is devoted to the development of ultrasonic methods that will be of practical use in medical applications. Recently a Doppler ultrasonic technique was developed to measure blood flow in vessels of the body. A continuous wave Doppler method was designed to detect malignant tumors in women's breasts by measuring the blood flow in such tumors.

Studies are being carried out to develop an ultrasonograph to visualize the interior structures of the eye. Other efforts are designed to obtain visualization of the heart in various pathological states.

While the thrust of the work done by two of the sections is directed to applications in medical diagnostic work, the third section, Ultrasonic Holography, headed by Zieniuk, places its emphasis on physics and basic research. This section has 6 staff persons and usually has the assistance of 1 or 2 graduate students as well. The major interest of Zieniuk and his colleagues at the present time is in ultrasonic imaging. However, Zieniuk's first brush with ultrasound was in the early 1960s when he became interested in measuring the energy (power) of an ultrasound (US) beam. In fact this work became the basis for his PhD thesis. Zienuk developed a device called the ultrasonic thermoprobe which he used to measure US intensity in liquids at frequencies of about 1 MHz. With calibrations, the intensity can also be obtained in absolute units of watts/cm² (W/cm²). The design that Zieniuk evolved permits a simple, rapid, and accurate measurement of US intensity. An absorbing layer of porous polyvinyl chloride in the form of a cone with concavity directed towards the US is attached to one side of a thin copper sheet, and a number of hot thermopile junctions are attached to the other side. The conical shape of the absorbing layer eliminates multiple reflections and insures absorption of the US. The thermoprobe is large enough (35 mm dia) to include the entire beam. Measurements of the thermoelectric emf versus time produces a curve of the type $emf = A(1-e^{-\alpha t})$, *similar* to those obtained for a nonadiabatic calorimeter. The time constant $1/\alpha$ is of the order of 1-3 minutes. Thus, readings can be taken easily and rapidly when a steady state has been reached. When calibrated against an absolute calorimeter, the emf may be interpreted in terms of watts.

Several years after his work with the thermoprobe Zieniuk received a fellowship from the British Council to work in Professor R.W.B. Stephens' Acoustic Group Laboratory in the Physics Department at Imperial College, London. There he continued his interest in the measurement of US power with calorimetric methods. He studied the properties of the nonadiabatic, nonisothermal calorimeter as an ultrasonic power measuring device. Zieniuk demonstrated that such measurements depend not only on US field characterizing quantities but also on the thermal parameters of the calorimeter: its energy equivalent, the cooling coefficient, and the time constant of the thermometer employed. These parameters indicate that the measurement system has its own internal time constants. Thus, to interpret such measurements one must know something about the instrument time constants in relation to the duration time of application of the US energy source. The conclusion of the study was that for US measurements

the most suitable calorimeter properties are: (1) a thermal energy equivalent (energy required to raise calorimeter temperature by one degree, under adiabatic conditions) as small as possible; (2) a high value of the cooling coefficient (amount of energy lost by the calorimeter per second for a one degree temperature difference between the calorimeter and its surroundings); (3) a thermometer having a small time constant.

Despite the universal employment of ultrasound for medical diagnostic purposes, relatively little work has been done in determining the absorbed energy when ultrasound interacts with human tissues. Part of the difficulty resides in the fact that much more must be known about the interaction of ultrasound with human tissues. However, considerable progress has been made in the measurement of the ultrasound intensity output, or what may be termed the exposure dose. This area is also fraught with many complications, and Zieniuk and a colleague (Prof. Robert Chivers, Univ. of Surrey, UK) performed yeoman service by reviewing the status of measurement of ultrasound exposure with thermal and radiation force methods.

Thermal methods depend on the conversion of the ultrasound into heat and the measurement of a temperature change. These methods are universal in application and can be used to measure continuous or pulsed waves, in the near or far field, above or below the cavitation threshold. The calorimeter used in these methods can be calibrated precisely by means of an electric current. Also included in this group are thermoprobes of the kind developed by Zieniuk. Usually these do not provide absolute values, but they can be calibrated by means of a calorimeter. The thermoprobes are very useful in exploring the relative values of field energy at different points.

The most commonly used methods for absolute energy measurement, however, depend on the determination of a radiation force associated with the ultrasound field. These methods are popular because of the relative simplicity with which such measurements can be made, but despite their popularity, they have given rise to controversy because of disagreements between individuals about the theoretical basis for the measurements.

Any body irradiated by an ultrasound beam is subjected to a force whose magnitude and direction depend on both the properties of the sound field and the size, shape, and material of the body. The existence of such an acoustic radiation force was noted by Dvorak (1876), but was first considered quantitatively by Lord Rayleigh in 1902. Years later (1920) Brillouin disputed some of Rayleigh's concepts of the momentum carried by the acoustic waves.

For plane, isothermal waves, Rayleigh derived the result that the radiation force Π is given by: $\Pi=(g/c)E\cdot S$ where g and c are the group and phase velocities of the waves, E is the energy density (the desired quantity) and S the area perpendicular to the wave direction. Thus, a measurement of Π plus a knowledge of the velocities would permit computation of E, the energy density. A few years later (1905) Rayleigh showed that for adiabatic waves in gases: $\Pi=\frac{1}{2}(1+\gamma)E\cdot S$ where γ is the ratio of the specific heats of the gas. However, these results were valid only for a restrictive condition of a fixed mass of fluid in a fixed volume (called the "Rayleigh" condition).

A more realistic method for measurement, and the one used by most experimenters, employs open vessels referred to as the "Langevin" condition. Brillouin, in 1925, and more recent authors (Beyer et al., in 1969) stated that in the open vessel situation the relation was: $\Pi=E\cdot S$. Other writers suggested that the properties of the propagation medium would affect the radiation force. One even suggested that the radiation force for plane waves was theoretically zero, and that the common observation of nonzero forces was due to artifacts (e.g., departure of the wave from planarity).

Clearly some experiments were needed to learn the truth. In 1972 Rooney and Nyborg attempted a simple analysis which confirmed the early result (used without exception by workers measuring intensity) that $\Pi=E\cdot S$ for the Langevin condition. For the Rayleigh condition they obtained a result for ideal gases of: $\Pi=\frac{1}{2}(1+\gamma)E\cdot S$ in agreement with Rayleigh. Rooney's experiments (1973) with three different liquids (water, ethanol, and n-propanol) confirmed that there was no dependence on medium characteristics within the limits of experimental error.

Thus, it appears that it is correct to assume that for plane waves the radiation force is given by just the product of energy density and the area intercepted. On this basis one may calculate the force associated with a given acoustic intensity. The energy density $E(\mathrm{erg/cm^3})$ and an incident energy flux $P\ \frac{\mathrm{erg}}{\mathrm{cm^2}}\ \frac{1}{\mathrm{s}}$ are related as: $P=E\cdot C$ where C is the group velocity of the acoustic wave in the medium. Thus, the radiation force is: $\Pi=E\cdot S=(P/C)\cdot S$. If $PS=1$ watt$=10^7$ergs/s and C is taken as 1509 M/S (in distilled water at 20°C), then $\Pi=66.3$ dynes = 67.6 mg (gravitational constant assumed to be 980 cm/s²).

Zieniuk and Chivers reviewed the dozen or more experimental systems currently in vogue which include measurement of the acoustic force by microwatt balance, suspended target, chemical balance, cartesian diver and others. The systems vary enormously in such matters as sensitivity (from 0.0015 to 50 milliwatts with many unknowns), range (from >0.0015 mW to 25 W with many unknowns), precision (reproducibility) (about 1 to 2% with many unknowns) and accuracy (from 3% to 7% with many unknowns).

One of the interesting features of the methods listed above and their experimental capabilities is the large number of unknowns. More surprising has been the lack, until recently (1974-75), of comparisons of results of two methods or systems using the same principle. The recent work shows spreads ranging from lows of 4% to highs of 25%. Zieniuk and Chivers believe there is a general level of agreement which appears healthy.

It is well to emphasize again that for noninvasive measurements in medical applications, one can only assess exposure doses. In order to be able to calculate what the absorbed dose will be in tissues, much more will have to be known about the way in which ultrasound interacts with human tissues. Such information will be vital in helping to form assessments of the effects of US on human tissues, and in determining whether any of these effects are deleterious. (Moses A. Greenfield)

METEOROLOGY

SATELLITE METEOROLOGY IN FRANCE

The Space Meteorology Center (Centre de Meteorologie Spatiale, CMS) near Lannion, France, is the primary center for satellite meteorology in western Europe. It was established in 1963 to improve weather forecasting in France. Because most weather systems affecting France approach from the west, the center was located in the westernmost part of the country. The center now is able to receive and process data from all meteorological satellites (except military satellites) within view. However, it does not receive data from Russian satellites on a regular basis because of lack of calibration information.

My host during a recent visit to the center was Dr. R. Lasbliez, the director. Lasbliez informed me that the center conducts training courses for students from developing countries, primarily African countries but also including some from Asia. Twice each year, the center conducts sessions lasting about 3 to 4 months, each with about 10 such students. The subject matter for these courses ranges from basic meteorology to the special techniques required to use satellite data in meteorology.

The center also conducts shorter courses lasting 1 or 2 weeks and intended primarily for Europeans who are working in developing countries or who intend to work there. These courses are for larger groups of up to 20 students.

The center made a great deal of use of the European geostationary satellite METEOSAT until its failure last fall and is awaiting its replacement, which is presently scheduled to be placed in orbit early in 1981. Luckily Lannion is just inside the zone of visibility of GOES East, the geostationary satellite over Ecuador. Its signals are received from near the horizon with a 12 m dish-shaped antenna which looks strange sitting almost vertically on one rim. Satellite imagery is processed with computerized man-machine interactive consoles called MENHIR and EMIR.

Nephanalysis, the study of cloud patterns and cloud motions, plays a more dominant role in meteorology in France than it does in the United States. I had first heard the word (which does not appear in *Webster's Unabridged Dictionary*) in my meteorology course in WWII when a French meteorologist gave us a short course in the subject. The center furnishes cloud data to forecasting centers in France and has used 12 years of historical data from satellites to construct an atlas of clouds over France and to develop a catalogue of cloud types.

Satellite sea-surface temperature data are collected routinely. While METEOSAT was in operation, the center furnished daily sea-surface temperature maps to a marine laboratory in Abijan, Ivory Coast, Africa, for distribution to tuna fishermen who use these data to locate oceanic frontal structures that are biologically rich and where tuna tend to congregate. The center also furnishes data on the Ushant oceanic front (*ESN* 34-8:301 [1980]) off the northwestern tip of France to biologists at the Roscoff Marine Biology Station and at the University of Brest, who are studying the chemistry and biology of the biologically rich waters associated with the front. It also publishes a weekly mean chart of oceanic fronts in the Mediterranean Sea for the French Navy. The chart for the second week of July 1980 showed the location of over a dozen fronts with temperature differences of 1° to 3°C plus upwelling areas and unusually warm or

cold areas. These charts are based on data from orbiting US satellites making 2 to 3 passes a day.

Another area of major interest and continuing research includes satellite-derived vertical temperatures and water-vapor profiles in the atmosphere. Six Raywind atmospheric sounding stations in France obtain regular soundings with balloons. The resulting information is used to calibrate satellite data and the satellite data are used to interpolate for areas between the Raywind stations. These anchor points and the satellite data provide a 30 × 30 km mesh of soundings over the whole of France.

The center uses data from NASA's HCMM (Heat Capacity Mapping Mission) satellite, which records thermal emission from soil, to map types of soils and rocks for geological studies. Temperature differences between day and night furnish information on the thermal inertial regimes. Experiments are being conducted in an endeavor to see if soil humidity can be determined for agricultural purposes. The use of HCMM data requires very accurate position fixing on the satellite images. The MENHIR console is used to remove distortion from the images and to determine latitude and longitude very accurately. Up to 31 landmarks that show up clearly on the images are used in the process. In the image I was shown a cursor was used to locate a clearly seen bend in a major river and the information was fed into the console.

Rain rates are estimated from radar and satellite data (*ESN* 34-7:345 [1980]). Jet streams are located from cloud movements. An estimate of the amount and the extent of dust blowing west from the Sahara desert out over the Atlantic is made from data from visual channels. Individual thunderstorms are watched in the south of France. Even clouds of locusts have been followed in northern Africa. (Wayne V. Burt)

OCEANOGRAPHY

MARINE GEOLOGY AT THE UNIVERSITY OF EDINBURGH

When I arrived at the Grant Institute of Geology at the University of Edinburgh a half-hour ahead of schedule, I was invited to take part in an oral examination of a PhD candidate. The custom at the institute is to have each candidate present a 30-minute outline of the research he intends to carry out as the principal requirement for the degree. The exam is scheduled after a student has been in residence for six months. Half a dozen staff members attend, and following the presentation, they decide then and there whether to require the student to leave the university immediately or allow him to continue his research, which must be completed in a total time of three years. This abrupt up-or-out system seems more humane than the practice in the US where students have been known to work for five years or more, only to be told at the end of that period that they were not well enough prepared to continue working for the doctor's degree.

A sophomore course in general oceanography is offered at the university each year. It is open to all students and is usually attended by about 50 to 60. Undergraduate geology majors may take an optional course in marine geology which is strongly oriented toward marine geochemistry and chemical oceanography. Usually 5 or 6 students are in residence at the Institute to do graduate research in marine or coastal processes.

My host was Dr. N.B. Price. I also talked with Sir Fredrick Stewart, FRS, the head of the department. Price, who is a marine geochemist, has followed three lines of research. He has studied the organic rich muds off southwest Africa and off the coast of Venezuela; he has determined the vertical distributions of iodine, bromine, and organic carbon in sediments and studied their relationships from a range of environments off the coast of Nambia; and he has studied about a dozen trace metals in phosphorites in the same area.

Currently Price is working on the chemical composition of suspended particulate material in the ocean. Most of his efforts are concentrated on the eastern tropical Pacific Ocean. He works with particles down to 0.4 μ in size, near the limit of resolution of the electron microscope. He has found variations in the composition of these particles in near surface waters which are related to the structure of the seasonal, near-surface thermocline.

Price is interested in the fallout of particulate matter and the precipitation of orthogenic substances such as barium, the dissolution of skeletal material, the transport of materials including iron and inorganic manganese away from active oceanic ridges, the composition of manganese nodules, and the chemical and bacterial alteration of organic matter in sediments. He believes that it is absolutely essential that we understand natural reactions in the oceans before we can properly predict the effects of man-made input.

Dr. R.A. Scrutton started out as a geologist and then became a marine geophysicist. In addition to his research in the Grant Institute of Geology, he teaches marine geophysics in the geophysics department. His first research was a three-year study of the geophysics of the Rockall Channel area northwest of Scotland that he conducted while he was a student in the Department of Geology and Geophysics at Cambridge University. Next he spent two years at the University of Capetown in South Africa working on the geophysics of the eastern South Atlantic. He still maintains research links with that university. From Capetown he came to the University of Edinburgh in 1974.

Most of Scrutton's recent work has been on the geophysics of the continental plateau and margin (Goban Spur) southwest of Ireland. He has studied the sedimentary succession and tectonic history of that area, the structure of the crust and upper mantle, and the continental margin fault that exists there. He has worked extensively for industrial firms, interpreting their seafloor seismic data for a large area southwest of Ireland, that extends across the shelf of the slope and into the abysmal plain. At the present time he is studying some of the very detailed magnetic survey maps of the area of Ireland that were recently released by the US Navy.

Dr. E.R. Sholkovitz is a marine geochemist. His research has been concerned with chemical reactions which occur near the mouths of rivers, estuaries, and Scottish sea lochs where fresh and salt waters mix. In particular, he has been interested in the removal of dissolved humic acids and iron by floculation during estuarine mixing. At present much if his research is concerned with the application of oceanographic chemical techniques to river waters in the UK and the lakes in Cumbria. Sholkovitz feels that the chemistry of lakes has not been studied as systematically as the chemistry of the oceans. He is studying the basic processes which control the distribution of dissolved materials in time and space in fresh water.

Dr. T.P. Scoffin is doing research on coral reefs, carbonate sediments, and limestones. On of his aims in a study of the process now at work in forming carbonate sediments at various latitudes, is to try to determine the latitude in which fossil limestones have originated. He has done a lot of work on the calcium carbonate budget of fringing coral reefs off Australia and in the Caribbean. Scoffin is also studying the budget of the sediments as well as in-place material. He has found that only about 10% of coral reef material is in place when it is fossilized. He uses dye to determine annual growth rates of corals under different exposures such as the windward and leeward sides and the insides of reefs.

The major prevailing forces tend to have observable effects. Thus, the study of reef structures through coring can give some information about the past history of the reefs. His next study of this type will be a joint effort with researchers from New Zealand on the coral reefs in the Cook Islands.

In addition to conducting studies of shallow reefs in low latitudes, Scoffin has recently done work on temperate latitude sub-photic carbonate sedimentation on the 20,000 km^2 Rockall Plateau west and northwest of Scotland. Carbonate sediments are presently accumulating there and are covering older rock outcrops. Scoffin used underwater television cameras and also examined bottom samples to study the environments of carbonate production and deposition. He found that the type of sedimentation was roughly zoned into concentric annular rings according to depth. Patches of living coral were found at depths between 200 and 400 m. The shallower areas were largely covered with coarse fragments of benthic organisms.

Dr. A.H.F. Robinson is a geological oceanographer-geochemist. He is studying records of sedimentation rock to try to determine the oceanographic conditions under which the original sediments were laid down. He uses cores from the ocean bottom and former marine rocks which have been uplifted and are now above sea level. Robinson is mainly interested in metaliferous sedimentary rock. He began studying iron and manganese in rocks from Cyprus, the Oman Mountains, Turkey, and elsewhere in the near East and the Mediterranean area. More recently he has been using core samples from the Deep Sea Drilling Project to study the geochemistry of continental margin sediments.

I was very much impressed by my visit to the Grant Institute. Most of the people I interviewed were engaged in international cooperative projects, primarily with scientists in the US. All the staff members were most helpful and very courteous. (Wayne V. Burt)

PHYSICAL OCEANOGRAPHY AND MARINE POLLUTION CHEMISTRY AT COB, BREST

The Centre National pour l'Exploration des Océans (CNEXO) was established by law in 1967. Its purpose, in conjunction with governmental ministries and public enterprise, is to sponsor and carry out research and studies aimed at recovering resources in, on, and under the oceans. CNEXO is a public body, industrial and

commercial in character, under the jurisdiction of the Ministry of Industry. It supports a large share of the marine research being carried out in French universities and laboratories.

CNEXO's own principal research laboratory, Centre Océanologique de Bretagne (COB), is located near Brest in the far northwest corner of France. CNEXO also maintains a small laboratory, Centre Océanologique de Pacific, in Tahiti. CNEXO has had six new research vessels designed and built since 1968. These vessels form a pool and are used by marine-oriented biologists, physicists, geologists, and engineers from various French governmental agencies, universities, and CNEXO. The home base of the fleet, Base Océanologique de Méditerranée, is located in Toulon.

COB is located on a 40-hectare (86-acre) campus on a high cliff, Pointe du Diable (Devil's Point) overlooking the estuary leading to Brest. It dates from 1974 and looks more like a new university campus than a governmental research center. COB employees (numbering 250 to 300) are housed in a dozen large buildings. Another 100 individuals from universities, other governmental agencies, and industry also work at COB. These are in small groups called "antennas". Foreign research workers—for example, persons on sabbatical leave—also are welcome.

The Department of Physical Oceanography is principally concerned with three topics: (1) Mesoscale features such as rings and eddies with life spans of 10 to 100 days and space scales of 10 to 100 km, (2) Ocean surface waves, and (3) The general-circulation oceanic climatology of the Eastern Atlantic.

The chairman of the department, Dr. F. Madelain, and his colleagues, Dr. Colin De Verdières and Engineer M. Arman, have been doing research on anticyclonic eddies well off the continental shelf west of Brest since 1976. In the first experiment which took place in cooperation with the NOAA Data Buoy Office, sixteen instrumental drifting buoys were tracked by the Nimbus F Satellite and confirmed the presence of a large anticyclonic eddy (*Océanologica Acta*, Vol. 1, No. 2, pp 159-168). The buoys were instrumented to measure and record near-surface meteorological parameters. A 100-m long thermistor chain below some buoys measured and recorded water temperatures. These time series were designed to study thermocline models as well as eddies.

Madelain lamented that of the 16 buoys launched only 7 were recovered *in situ*. Four were picked up and taken away by Spanish trawlers. Unbeknownst to the fishermen, the buoys went on talking to the tracking satellite; as a result, the passage of the trawlers into Spanish ports was easily followed and the buoys were recovered. (Fishermen are a bane to small surface buoys. They have taken mine in the North Sea, near Okinawa, and off the coast of Oregon.)

After an analysis of the data, many questions appeared. Was the eddy an isolated case and a lucky find, or is much of the ocean filled with such eddies? What are the water mass characteristics in, around, and under an eddy? How long does an individual eddy last? What is the vertical extent of an eddy? Mean velocities within the eddy were almost an order of magnitude greater than the mean current in the area where it was found. Where does all this kinetic energy come from?

All these questions and others prompted Madelain to set up a major experiment (Turbillon) to measure as many characteristics of an eddy as possible in sufficient detail to provide answers. He found willing collaborators in the UK Ministry of Agriculture and Fisheries Laboratory in Lowestoft, the SACLANT ASW Laboratory in La Spezia, Italy, and the Physical Oceanography Group in the Museum of Natural History in Paris (*ESN* 33-5:78 [1979]).

First, a series of exploratory cruises was carried out in May, June, and July 1979. A favorable site for the main experiment was chosen based on the interpretation of XBT data and the trajectories of the free-floating buoys. The site selected was in 4000 m of water on the abyssal plain a third of the way between the edge of the continental slope and the Mid-Atlantic Ridge centered about 800 km west of Brest. The intensive part of the experiment continued through September and ended near the end of October. Ten current meter moorings were put out in a square area about 90 km on a side to be recovered in the spring of 1980 (all were successfully recovered). At the same time 13 neutral density floats were launched at depths between 700 and 2000 meters. A square grid of 40 CTD (conductivity-temperature-depth) stations was established with distances of about 22 km between stations.

Two ships at a time were used for the 2-month CTD survey so that the coverage of individual surveys could be as near synoptic as possible.

The reseachers had made a judicious selection of the site for study. The float study indicated that the center of the eddy had shifted slightly to the east of the center of the array. During the experiment the eddy drifted slowly to the NW across the measuring network.

Madelain is now working up the results of the experiments. Some very interesting facts are showing up. First, the data on currents from the trajectories of the Lagranian neutral density floats agrees remarkably with the Eulerian current meter data even to fine detail. One side of the eddy had a persistent strong temperature front with a 2°C change of temperature at the surface. Inside the eddy, Mediterranean water (*ESN* 33-10:425 [1979]) showed up as a strong deviation in the temperature salinity diagrams at 800 m with large increases in temperature and salinity.

There was positive evidence that the eddy extended to at least 2,650 meters in depth and some evidence that it may have reached all the way to the bottom at 4,000 meters.

The temperature and salinity structure of the eddy was complex, particularly at the level of the Mediterranean water. Vertical excursions of isotherms at the level of the main thermocline on the order of 200 m were observed.

Madelain's group intends to work on Turbillion data for the next two years. In the next large experiment scheduled for 1983 they plan to examine the influence of the Mid-Atlantic Ridge on the Gulf Stream. They hope to make it another international effort with collaborators from either the UK Institute for Oceanographic Sciences or the German Institut für Meereskunde in Kiel.

Research on ocean surface waves is being carried out by Dr. A. Cavanie and his collaborators, Mr. M. Ollitrault and Engineers R. Ezraty and M. Arham. Cavanie spent 13 years in the US where his parents taught French. He spent some time studying oceanography and meteorology at MIT but received his PhD in mathematics at the Sorbonne in Paris.

The group has been studying problems linked to wave measurements and analysis. The researchers have designed and built the very latest state-of-the-art pitch and roll buoy to record wave spectral data. The buoy was originally designed to obtain ground truth on surface waves for SEASAT but was not finished until after SEASAT had quit transmitting data. Previous deep-sea wave recorders that I am aware of required a lot of electrical power and thus either had to be connected to a ship with an umbilical cord to furnish power, or, if free-floating, could only record for periods of 2 to 4 hours depending on the model. They capsized rather easily in rough weather. To obtain data in real time requires the use of either the umbilical cord or radio transmission with its attendant problems of radio noise.

Most of the above problems have been solved. The latest COB model is spherical with a 2.5 m diameter. It can be anchored or operated in the free-floating mode anywhere in the world. A microprocessor on board the buoy does a spectrum analysis. The buoy transmits these spectral data via satellite and thus eliminates radio-transmission problems. Flux gate meters replaced the electricity-eating gyro of previous models, and best of all, the buoy will operate unattended for up to four months, three orders of magnitude longer than older models. Maximum wave heights of 8 m have been measured without trouble and Cavanie believes that the buoy will operate successfully in much rougher seas. The instrument was used successfully during the summer of 1979 in the international North Sea in the Marine Remote Sensing Experiment, MARSEN.

The Wave Group has a mobile decca-metric radar system for obtaining wave data from the shore. It has been used in MARSEN and around the Bay of Biscay. The next radar-wave experiment is scheduled to be run from October to December 1980 from the Shetland Islands.

The Wave Group has done a great deal of research on the range of wave periods to be associated with the "design wave" (highest expected wave in 50 or 100 years). They have used their own data collected during extreme storms in the North Sea. Data totalling 340 hours were collected from 21 major storms. Historical data from other sources were also used to determine a period range of 14 to 17 seconds for a North Sea design wave 30 m in height. The researchers have determined the statistical relationship between individual wave heights and periods in severe storms and have done theoretical and experimental studies of statistical relations between successive wave heights resulting in correlation coefficients between successive wave heights of 0.29 for "growing seas" down to 0.19 "fully arisen seas".

Presently the Wave Group is working on the characteristics of the spread of direction of waves under various conditions using Gaussian noise sound theory.

Dr. C. Maillart is carrying out an analysis of all historical CTD data in the eastern North Atlantic to determine the statistical distribution of temperature salinity and geostrophic currents. The first task is to determine the mean field from 20 years of data at 21 depth levels to 2,000 m on a 2° by 2° latitude and longitude grid over the area from 20° to 50°N latitude and 0° to 40°W longitude. The main aim is to study the statistical characteristics of the Gulf Stream east of the Mid-Atlantic Ridge.

The Mediterranean water (*ESN* 33-10:425 [1979]) clearly shows up with its high salinity and temperature at a depth of about 1,000 m over much of the area. No permanent currents, but only some weak eddies were found to be associated with the Mediterranean water indicating that the movement and spreading in deep water seems to be due to diffusion.

Maillant used Tyros N data to look for evidence of the large eddy or ring that was studied by Madelain but did not locate it because of clouds. Some hints of other eddies were discovered.

Dr. J.L. Mauvais is head of the Marine Pollution Chemistry Group which is a part of the Department of Coastal Environment and Management of the Marine Habitat (Environnement Littoral et Gestion du Milieu Marine). The group consists of six researchers and six technicians. Funding comes from the Ministry of Environment and Quality Life. Its primary task is concerned with marine and estuarine pollution. Research and monitoring is done on heavy metals, organic pesticides, dissolved nutrients, organic matter, and toxic effects of various pollutants on marine organisms.

There is an ongoing program to improve analytical methods for determining the concentrations of various pollutants.

The department acts as the head coordinator of all marine pollution studies in France. It is the national calibration center for analytical methods used in marine pollution monitoring. It is responsible for determining standard methods for sampling, pretreatment of samples, and the analytical methods used in France. All data on marine pollutant concentrations is sent to the department where it is gathered together in a data bank. It is edited and the results are published from time to time.

Special studies have been made on the fate of copper from antifouling paints. Little copper has been found in either solution or marine organisms. Most of it ends up bound to sediments on the bottom. Research on the chemical kinetics of heavy metals in seawater is also underway.

The only deep-sea work done in the laboratory has been the determination of the metallic composition of seafloor nodules from the area between Mazatlán, Mexico, and Tahiti. In 1981 this work will continue in the Pacific aboard Scripps Institution of Oceanography (SIO) RV *MELLVILLE* in a cooperative program with SIO.

The new (2-year old) Organic Chemistry Section is concentrating on the mechanics of transfer and distribution of DDT, Linlane, and PCBs. Usually one or two students from Paris are working on PhD thesis research on the above problem although the department does no formal teaching.

Oil pollution research plays a major roll in the department which coordinates all studies related to the big *AMOCO CADIZ* spill. Department members also took part in the study of the Mexican oil spill that occurred off the east coast of Mexico in 1979.

COB is situated in Brittany, one of the loveliest areas in France. The laboratories are spacious and beautifully situated. The persons that I interviewed were enthusiastic and carrying out interesting research. Built to replace a city that was almost completely destroyed in WWII, Brest is a new, modern, light, and airy city. For all the above reasons I would recommend COB as a good place for a sabbatical. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH IN ICELAND

Family names do not exist in Iceland. My host, Sigfus Björnsson, has the same last name as his brother, Sveinbjörn Björnsson (mentioned in an ONRL Technical Report), but his parents, sister, wife, and children all have different last names. Specifically, his father's first name was Björn and so his sister's last name is Björnsdottir, a name which she retains after marriage. His wife's and mother's last names are whatever their maiden names were, and his children have the last name Sigfusson or Sigfusdottir, depending on their sex.

Iceland is a very small country with less than a quarter of a million people. All of the operations research (OR), and indeed virtually all of the intellectual activity in the country, take place in the capital, Reykjavik (the second largest city has a population of only 13,000). Much of this intellectual activity revolves around the University of Iceland. The remainder is mostly associated with various government offices in Reykjavik. The university has an enrollment of 3,000-4,000 students, of whom some 500 are in the Faculty of Engineering and Science. These students require three years to get a Bachelor's degree in science, and four years to obtain one in engineering.

There is essentially no graduate work; bright students are encouraged to go to the US, the UK, or Scandinavia for graduate study. All of the scientists I met had indeed taken their degrees elsewhere, and all of them spoke excellent English in addition to Danish (because Iceland used to be a Danish colony and is still very close to Denmark). Their

native language, Icelandic, is very similar to old Norse; the land was colonized starting in 874 A.D. by the Vikings, and since the island was isolated, the language has remained rather stationary there while back in Norway the Norse language has evolved considerably.

The faculty members at the University of Iceland are supposed to spend 40% of their time teaching (in practice this amounts to four hours of lecture per week for 30 weeks of the year), 10% in administrative work, and 50% in research. The research is mostly done through institutes, there being separate institutes for engineering and science. Some of the research at these institutes is government sponsored; other research is sponsored by industrial or commercial organizations, or even by individual government agencies.

Sigfus Björnsson is an associate professor of electrical engineering who does his research through the Engineering Research Institute, and who this year is one of the three members on the Board of that Institute. He holds a diploma in physics from Aachen, a candidate in physics from Zürich, and a PhD. in electrical engineering and bioengineering from the University of Washington. Björnsson's primary research interests are in signal processing applied to biological and bioengineering systems, but he stresses that while most people have biomedical aspects in mind when they talk about bioengineering systems, he does not. Specifically, he is interested in fishing gear and how to optimize the design of such gear with respect to the biology of fish—that is, how to apply signal-processing theory and sensory physiology to develop better fishing gear—as well as aquaculture. He is doing research into the nature of the fish's eye, and especially the fish's retina, which is an extraordinarily complex device. He notes, for example, that fishing gear triggers bioluminescence (in diatoms), and as a result, the net is visible to the fish as a silhouette against a light background. The question is whether changes in the design of the net can alter the behavior of the fish in response to such signals.

Björnsson's interest in aquaculture refers to ocean ranching of salmon. Iceland has many salmon rivers, for which it is well known throughout the world. After some years in the ocean, salmon return to the river in which they were born. Since salmon fishing in the ocean is strictly prohibited, a farmer who sows young salmon ("fry") may get them back some years later. Unfortunately only about 5% on the average do return, and even this number varies greatly from year to year. Hence there is some talk of a "closed system." The salmon must get to salt water to grow, but it may be possible to keep them in nets or cages or some other form of confinement in the salt water. Furthermore, it is possible to heat the salmon streams, using Iceland's virtually boundless geothermal hot water (see ONRL Technical Report) and salmon grow much faster in hot water than in cold; but so do most other organisms, including those which parasitize the salmon, which leads to the necessity of sophisticated ecological studies.

Working with Björnsson is Gudmundar Einarsson, a research associate at the Physiological Institute at the University of Iceland. Einarsson is a full-time researcher employed by the university without any teaching responsibilities. He took his BS at the University of Iceland in biology and an MSc at the University of Birmingham (UK) in neurocommunications, and is now working for a doctorate at the University of Montreal in fish vision. He is particularly interested in the retinomotor responses, in which the rods and cones in the retina move back and forth in response to light; there seems to be some endogeneous pattern to the movement, which continues even in a constant photic environment. In the same institute, L. Jonsson is working on olfaction in fish, testing their thresholds to various chemicals in the water, and in particular testing pheromone theories explaining how each salmon finds its own river. It seems probable that the salmon follows several cues simultaneously, but it may be possible to imprint a certain chemical on the salmon which are planted in a particular river as fry, then bring them back some years later to the same river, or even to a different river with the same chemical.

The Engineering Research Institute is headed by Prof. J. Axelsson, who has doctorates in pharmacy from Oxford and in physiology from Lund (Sweden). His research is on the comparison of Icelanders who have remained in their native land with the extremely large group of Icelanders who emigrated about 1890, settling in massive enclaves in Manitoba and North Dakota where they have had virtually no intermixture with the local populations. Axelsson has some very interesting contributions to the old nature-nurture controversy, inasmuch as these two groups, which have virtually identical heritages, have quite different disease patterns.

Also doing OR on fish is Páll Jensson, the head of the computer center at the university. (That so much work is done on fish is not unrelated to the fact that fish constitute 70% of Iceland's exports, as well as a large fraction of the protein food consumed domestically.) Jensson

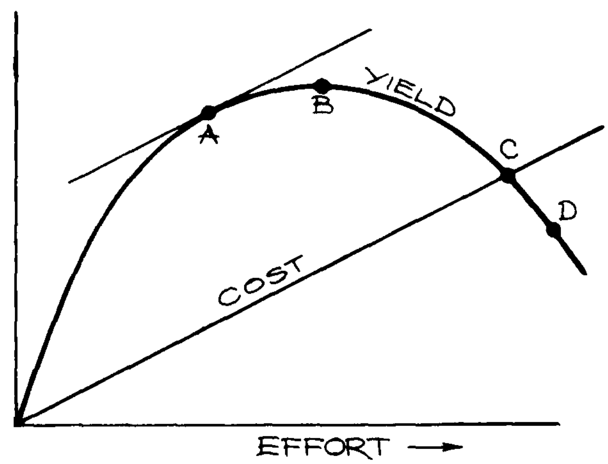
took his licentiate (comparable to the doctorate) under the well-known OR specialist Arne Jensen in Denmark. His thesis concerned stochastic programming applied to fishing problems, but his work now is strictly applied. What OR instruction there is at the university is given by the mathematics professors in the Computer Center and, as indicated above, is confined to the undergraduate level.

The fishing fleet follows the schools of fish, and the ships therefore tend to be concentrated geographically. To save the time and expense of sailing farther than necessary after they have made their catch, all the ships put into the same harbor at about the same time to dispose of their fish. This creates tremendous congestion in that harbor, while other harbors and their associated freezing and fish-processing plants are idle. Jenssen and his co-workers have applied queuing theory to this problem, together with simulation, and in particular they have investigated some proposals by the government to avoid these problems by subsidizing the boats to go to different harbors; the proposals are not being implemented because Jensson's studies have shown that the subsidies would have been too expensive.

Another example of OR application involves fishing for capelin, a common species of fish. There is a certain quota that may be taken during the 36 weeks of the fishing season, and this quota can be collected in a good deal less than 36 weeks. Hence there is a decision to be made at the beginning of each week as to whether or not fishing should be undertaken during that week. This becomes a standard dynamic programming problem, with some complications due to the stochastic nature of some of the constraints.

One of the OR workers on the staff, Oddur Benediktsson, is studying the feasibility of putting minicomputers on each boat in the fishing fleet. These computers would do routine navigational and inventory calculations, and in addition would forecast where the schools of fish are going to be and update position information, as well as "talking" with the computers on other ships to exchange information.

Jensson drew the attached diagram for me, representing the classical economic picture of how, as the amount of fishing effort increases, the yield first increases and then eventually starts decreasing as overfishing diminishes the population. The maximum profit occurs at point A, the maximum yield at point B, and the classical economic equilibrium at point C. At present, Iceland is at point D, due largely to subsidies which effectively reduce the cost of fishing. The obvious solution would be to decrease or render negative these subsidies by putting a tax on cod (cod is the principal revenue fish caught in Iceland), but while this is technically optimal it seems to be politically infeasible. Instead, there are various complex government regulations which do not work very well. For example, no cod fishing is permitted in July and at numerous other times during the year adding up to approximately 100 days. However, fishing for other species is permitted during this time, provided not more than 15% of the catch is cod. What happens is that the boats go out and catch whatever they can, and then throw away enough cod so that they come home with no more than 15%. This kind of inefficiency resulting from government regulation and interference with the free market is, in Jensson's opinion, partly responsible for the terrible inflation ravaging Iceland (now about 50% per year). His group has simulation models on the computer to find the effects of various government policies. These simulations are rather complex: there are several regions, each comprising a group of harbors; there are several different species of fish; there are several classes of boats; and there are several types of fishing gear (including nets, lines, trawls, and the like).



Jensson told me of one particular simulation, some 10 years ago, when virtually the entire fishing fleet was replaced and 70-80 new trawlers were bought. The question was whether the trawlers should be small (about 500 tons) or large (about 1000 tons). The smaller vessels can carry about 250 tons of fish while the larger hold about 500 tons. The larger vessels have better ability to fish in bad weather, and,

of course, they do not have to come back into harbor so quickly if the fishing is very good because they have a larger fish-storage capacity. Furthermore, the big trawlers can catch fish slightly faster than the smaller ones. However, the simulation made clear that small trawlers would be more efficient than big trawlers. Apparently the big trawlers could not stay out long enough to reach their full capacity anyhow, and it turned out that the union contracts made smaller trawlers more advantageous to the owners because they specified unnecessary employees on the larger ones. Furthermore, that weather which was just bad enough to keep the small trawlers from going out but not bad enough to keep the large trawlers in turned out to be quite rare. The man who directed the simulation study, which was widely ignored at the time but which later turned out to be entirely correct, was named Johannesson, and he subsequently became minister of fisheries in the Icelandic government (he is now back in the university's Computer Center).

Another member of the staff, Thorkell Helgason, is building mathematical models of the population of cod (the decreasing population of this fish, due to overfishing, is threatening the very lifeblood of the nation). The basic differential equation governing population is $dN_i/dt = (f_i + m_i)N_i$, where N_i is the number of fish in the ith age group, m_i is the natural mortality rate of the fish, and f_i is the mortality rate of the fish due to fishing. Furthermore, $f_i = \Sigma_g q_{ig}E_g$ where q_{ig} is the effectiveness of the gth type of gear on the ith age group, and E_g is the effort in the gth type of gear—that is, the number of boats using that gear or the number of gears of that type being applied to fishing. After that model had been formulated, it became apparent that nobody worried about q and that no adequate data were available on it. Efforts are now underway to obtain such data. The model is, of course, much more complex than this. For example, there is interspecies competition (the cod eat the capelin). The model bears considerable resemblance to that of Ben-Israel described in *ESN* 34-4:194 (1980).

While almost all the OR is understandably on fishing, Jensson did speak about a couple of other projects. Iceland's electric power plants require decisions from time to time as to whether to draw down water from a reservoir behind a dam or to fire up diesel engines to drive the turbines. This turns out to be a fairly conventional dynamic programming problem, and the conclusions were confirmed by simulations and then applied. There was also some linear programming (LP) work done for a dairy which involved making decisions whether to grow or buy foods of various types over a one-year planning horizon, and in particular how many cows to maintain at the dairy. LP was applied as well to a contingency plan for transporting hay between regions in the face of possible catastrophy such as volcanic eruptions. The latter are not uncommon in Iceland, but that is the subject of a separate article, published as a Technical Report (R-2-80). Robert E. Machol

OPERATIONS RESEARCH IN HUNGARY

Hungary is a small country; it now has about 10 million people, with a large number of additional ethnic and linguistic Hungarians in neighboring countries who were separated from Hungary in the treaties following World War I. But it has never lacked for more than its share of first-rate mathematicians and scientists, including half the leading scientists who built the atomic bomb in the early 1940s, and also including John von Neumann whose work underlies so much of operations research (OR). Yet there is little OR in Hungary today. It is hardly taught outside a single university, the Eötvös Loránd University, where it is an optional specialty within the Mathematics Department. The degree most nearly corresponding to our BS is the "diploma" given after 5 years; OR students at Eötvös specialize in this subject during their final 2 years. A few students also go on to the PhD, to the "candidate" (given by the Hungarian Academy of Sciences rather than by a university and roughly equivalent to the PhD), or to the ScD, which, as in most European countries, is a much higher-level degree than anything given in the US. There are significant practicing OR groups only at 2 or 3 of the country's research institutes; together with small groups attached to several of the ministries, this makes up virtually the entire professional OR activity in the country. There is no OR society, although Dr. Prekopa (see below) is trying to have one set up under the Academy of Sciences to seek affiliation with international OR groups.

The dean of OR in Hungary appears to be András Prekopa, who took his candidate in mathematics in 1956, received the ScD in OR in 1971, and became a corresponding member of the Academy of Sciences in 1979. He taught the first OR and linear programming (LP) courses in Hungary at Eötvös in 1958, and introduced OR as a specialization for mathematics students studying for the diploma in the early 1960s. Prekopa moved to the Technical University of Budapest in 1968, where

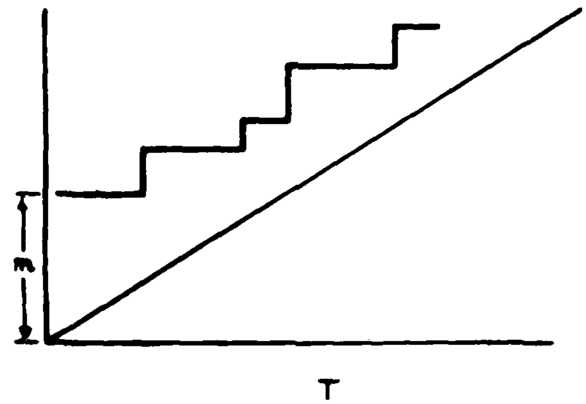
he teaches mathematics but has been unable to introduce OR courses. His position there occupies half his time; for the other half he is head of the applied mathematics branch of the Computer and Automation Institute of the Hungarian Academy of Sciences, for which the acronym is SzTAKI (Sz, pronounced "ss," is considered a single letter in Hungarian, alphabetized between S, pronounced "sh," and T). The Sz stands for the Hungarian word for computation, T is for technical, A is for automation, K is for the Hungarian word for research, and I is for institute. He also continues to teach at Eötvös, but on a part-time basis.

SzTAKI is one of the largest institutes of the Hungarian Academy of Sciences, having almost 700 people of whom some 400 are professionals. Prekopa's branch, one of 6, has about 50 professionals. He has been especially interested in stochastic programming, and continues to publish on it—most recently in a book with that title edited by M.A.H. Dempster and published this year, by Academic Press; and in an article on an electricity scheduling problem discussed below. He also has innovative ideas about teaching, and is presently discussing a course in LP for high-school students. While he is by no means old, he has all the wisdom of an elder statesman.

The OR Department in Prekopa's branch, containing about half the personnel of the branch, is headed by László Béla Kovács, who told me that he received his candidate in mathematics in 1962, although that implies an age considerably greater than his appearance would suggest. Since there was no OR available at that time, he studied mathematical physics. Now he and many of the members of his staff teach in the rather large OR program at Eötvös, and they recruit almost all of their personnel from their own graduates—there are only 2 engineers in the entire department, all the others being mathematicians. They have a comparatively small computer (CDC-3300), but they have obtained a Simula compiler for it; Kovács is convinced that Simula is the best general-purpose computer language as well as the best simulation language, and it is used almost exclusively by people in his department. Among the problems they are working on are the following three:

(1) Scheduling of electrical energy for the entire country. When applied over several years, this is the stochastic programming problem mentioned above. There are 4 stochastic constraints, each of which involves a right-hand-side parameter which is a random variable. The first two constraints are that the deficit in dollars and the deficit in rubles should not exceed certain amounts; the third is that the demand for electric energy should be met; and the fourth is a technical constraint involving input/output considerations. On a short-term basis, the scheduling involves a large mixed-integer programming problem for the daily scheduling of electrical energy production from 20-odd power stations, all fired by oil, gas, or coa — nuclear energy will first come on stream in Hungary in 1982. The objective function is to minimize total cost, based on different production costs for different types of fuels and different levels of power, together with the costs of changing from one mode to another. Also, there are different demands at different points, and it is somewhat cheaper to meet these demands locally, because of the I^2R losses in the lines if power is transmitted over long distances.

(2) Work at Duna Uj Varos (Duna means the Danube River, Uj means new, and Varos is the name of a town) steel works. Programmers there are developing a system language which will completely describe the operations of the plant for a digital computer, and they are developing both production-control and inventory-control systems. Prekopa told me that he was pessimistic about the production-control system, because that should be done by people with the necessary local information rather than by mathematicians from another organization. On the other hand, Prekopa felt that the inventory-control work would be successful. As explained to me by Péter Kelle, one of the mathematicians in Kovács' department, there are a number of inventory-control studies going on there, some based on unusual local conditions. The stochastic nature of the lead time (that is, the possibility of a random delay in the delivery of an order) is a conventional aspect of inventory-control theory. Kelle's special studies involve the possibility that the delivery will be piecemeal. The figure shows a graph of supply and demand against time (p. 491). The straight line is the demand curve. There is some initial supply m, and additional supplies are received at times and in amounts determined by some joint probability distribution. The problem is to determine the quantity m so that the supply line remains always above the demand line over some time horizon with at least a specified probability; that is, to minimize the quantity m subject to the above constraints. The applicable techniques are based on the statistics of Kolmogorov-Smirnov. This is Kelle's doctoral thesis, which will be published in English.



(3) Ecology. This work was described last month (*ESN* 34-9:434 [1980]).

This group at SzTAKI is the largest OR group in Hungary, and they are working on several other problems. However, many of these seem to me to be efforts without application or much hope of application. For example, they are building a model to determine the release of water from reservoirs, but they seem to be unfamiliar with recent sophisticated analyses of these problems (*ESN* 34-4:193 [1980]). They are making a model of a bus built by Icarus, a Hungarian manufacturer, to determine the minimal weight of the skeleton of the bus, given certain constraints on performance. Some of the more pessimistic members of the group told me that most OR work in Hungary does not get implemented, and I heard "horror stories". One of these was about a project to integrate the numerically controlled machine tools in a factory in a highly sophisticated way. They naturally asked what the objective function was—were they trying to minimize costs or to minimize the amount of labor or materials required? They were never able to get a satisfactory answer to this question; that is, to the question of why anybody wanted to integrate these tools in the first place. Another "horror story" concerned a project involving computerized diagnosis and computerized analysis of diseases. They had obtained an extraordinary collection of data on some 20,000 patients with thyroid diseases of one sort or another. They wanted to determine something about the diagnosis, and also what were the cardinal symptoms and the like. That is, they were building both biological and statistical models. However, they required about 80,000 forints ($4,000 at the official rate or considerably less at the free-market rate) to punch the data onto cards in order to get it into the computer. This money was never made available, and so the project was dropped after all the data had been collected and many of the preliminary models built.

I was told that both SzTAKI and other analogous research organizations obtain much of their support from contracts. I questioned why contract money continued to come in if the success rate on projects was low. It appears that in many cases firms are given money by the government "for development," and the easiest thing to do with it may be to give it to an OR project even if the managers have no intention of following the recommendations that arise from such a project.

The second largest OR group in the country is at SzAMKI, the Research Institute for Applied Computer Sciences. The OR work is headed by Aladár Heppes, whose group includes about 50 people, half of whom are in data processing while the other half are in OR. Again, there seems to be some competent OR work done here as well as some busy work. Among the successful applications they told me about were the following:

(1) A production planning model for a screw manufacturer. The object is to maximize the profit, and the variables are different types of screws, different ways of producing each type, different materials, and the like. It turned out to be an incredibly large LP model, with over 10,000 constraints and 200,000 variables. Fortunately it was doubly decomposable; that is, decomposable into smaller problems each of which in turn was decomposable into smaller problems. They used the Benders decomposition algorithm. It turned out that many of the blocks resulting from the second decomposition were either transportation problems or generalized transportation problems, and they developed specific algorithms for the latter.

(2) Some fairly conventional trim problems for an iron manufacturer. They solved and implemented a straightforward one-dimensional trim problem many years ago which has been working successfully in practice, and are now working on a two-dimensional trim problem involving iron plate.

(3) A unique production-control problem involving pharmaceuticals. About 100 different kinds of products (specifically, ampuls of vaccines) were being produced in each particular planning period of 1-month duration. The unusual constraints were that, because of the fear of mixing one product with another, two

different products were never allowed in the same room at the same time unless they looked very different from one another (for example if they were quite different in color). Rather than attempt to optimize as a zero-one programming problem, they were able to find a satisfactory near-optimal solution using a PERT software package supplied by the computer manufacturer.

Heppes' group has solved some scheduling problems, and the solutions, they told me, are being used routinely in certain factories. They have also done some statistical work. I was intrigued by one story they told me about determining the necessary sample size to estimate the sugar content of beets. This is a fairly straightforward theoretical problem, but in practice there are difficulties in getting a truly random sample. The interesting conclusion in this study was that it was cheaper to overpay a little than it was to take a larger sample to get the precision that was originally thought requisite.

I also visited the office of the applications section of the central statistical office of the computer center of the state administration. This section is quite large, with about 140 people; its head, Benedek Srajber, and 20 of his people are housed in 5 rooms of a high-rise residential building in Buda (Buda is the hilly half of Budapest on the north side of the Danube; most of the offices including that of SzTAKI, are in Pest, the flat city on the south side of the river). This indicates something of the shortage of building space, for commercial work as well as for housing, in Budapest, a city of some 2 million people. They are working on a number of projects, of which few seem to me likely to be successfully applied. Most interesting were some demographic studies on morbidity and on births. They have, for example, constructed a data base from more than 110,000 births in Hungary in 1970, and used this in several analyses. For example, they have attempted to determine the causes of premature births. Using both conventional statistical methods (factor analysis) and some unconventional methods from information theory (maximizing mutual information), they determined the factors most important in causing prematurity. One of the controversial questions was whether smoking habits of the mother increased the probability of prematurity; this study definitely concluded that it was an important risk factor.

Hungary is in many ways freer and more market oriented than most other socialist countries, although, of course, far less market-oriented than the western countries. This often leads to a lack of incentive which makes it difficult to implement optimal or near-optimal procedures. While Hungary has many first-rate mathematicians and continues to do first-rate work in the theory of OR, I was disappointed in the small number of OR applications that I was able to find and the small number of people who understand how to apply OR. These latter were confined almost exclusively to two organizations, SzTAKI and SzAMKI, described above. (Robert E. Machol)

OPERATIONS RESEARCH IN SPAIN, II: ACADEMIC

In most Spanish universities, operations research (OR) is taught in the Mathematics Department, or occasionally in the Department of Economics. While there are management schools in some Spanish universities, OR does not appear to be taught there, and there is little applied OR in any Spanish university. In mathematics departments, OR is taught as a specialty during the last 2 years of a 5-year course leading to the licentiate, roughly equivalent to our BS. But even in these two years, the curriculum tends to be highly theoretical—at the University of Madrid it includes a course in "análisis funcional"!

There are several universities in Madrid. At the Autonomous University of Madrid, an OR course is being taught this year by Antonio Vazquez Muñiz, an employee of the IBM Scientific Centre, in the Mathematics Department, and another is being taught by José Luis Gasco Catala in the Economics faculty. Both of these men were mentioned in "Operations Research in Spain, I" (*ESN* 34-9:462 [1980]).

The university most commonly called "The University of Madrid" is officially the "Universidad Complutense de Madrid." Complutense means the confluence of two rivers, and refers to the original location of the university which was on such a confluence several kilometers outside Madrid.

The Department of Statistics and Operations Research at this university is headed by Sixto Rios Garcia, who appears to be the dean of Spanish OR. Rios has been the head of the Society of Statistics and Operations Research since it was formed several years ago, and he is also head of a research institute in the Consejo Superior de Investigaciones Cientificas (Superior Council of Scientific Investigations), an institute which is to be absorbed into the university in the near future. He has over 100 publications and several books, mostly on statistics and almost all in Spanish. He speaks little

English, which is not uncommon. I found less English spoken by OR people in Spain than in any other European country I have visited. With a single exception, all of the OR people I met in Spain had taken all of their degrees in Spain, and hardly any could carry on a conversation in English (except those at IBM, almost all of whom were fluent). Rios' current research is in statistics, especially on mathematical aspects of the distribution of prior probabilities in Bayesian statistics.

Juan Béjar Alamo is vice director of the Institute of OR and Statistics of the Superior Council of Scientific Investigations and secretary of the Statistics and OR Society. Béjar is an actuary, holds professorial rank in Rios' department, and he told me (through an interpreter) that his research involved applications of linear and nonlinear programming to the cultural development of Spain.

There are altogether 31 people in this department; only Rios has a chair; 6 others have doctorate and professorial rank; and 24 with the rank of instructor are mostly doctoral candidates.

Prof. Miguel Angel Gomez Villegas is a statistician who works in the sensitivity (robustness) of Bayesian decision models. Gomez has recently completed an interesting experimental investigation of normative decision theory. He tested a large number of subjects to determine whether they behaved coherently with respect to certain axioms concerning stochastic dominance and the like. For example, he asked "Would you prefer event A with probability X to event B with probability Y"? Most people, when subjected to a series of such interrelated questions of increasing complexity, respond irrationally if not incoherently. Gomez gave this test to numerous businessmen and to numerous students of statistics. As I would expect (although Gomez thought it surprising), the statistics students did better than the businessmen according to these normative criteria. This study was funded by a government ministry, a although such government funding of university projects is not very common. Other work in this department is on data analysis, mathematical programming, stochastic control theory, and automata theory. There is also a new government-funded project, just begun, to study traffic accidents on intercity highways.

The head of the Department of Mathematical Statistics and Operations Research at the University of Seville is Prof. Rafael Infante Macias. Infante's research has been in stochastic programming, and he is now attempting to apply stochastic programming techniques to integer programming problems. OR is taught only in this department and only at the undergraduate level. Most of the research in this department is of a highly theoretical nature.

Several people are working on location problems of one sort or another. Prof. José Muñoz Perez has solved a problem posed by E. Minieka (Univ. of Illinois at Chicago Circle) in which there exists a network with demands arising not only from the nodes of the network but also anywhere along the arcs (for example, automobile accidents, which may occur anywhere along the roads between cities). The problem is to locate a point whose average distance from all demands is minimal. The solution turns out always to be either at a vertex or at the midpoint of one of the arcs. This solution then has been applied to the location of a hospital.

Blas Pelegrin, an instructor in the department, has treated a similar problem in which the demand may arise anywhere in the plane. Still another instructor in the department, Juan Antonio Mesa, has considered the problem where the demands change discretely over time and hence may be modeled as a Markov process.

I also visited the Department of Mathematical Statistics in the Faculty of Sciences at the University of Granada. I had received a most cordial letter in English from Ramiro Melendreras Gimeno, the director, inviting me to visit and to lecture. It turned out that, to be polite, he had had his letter translated into English. He could not speak a word of English, nor could any other member of the faculty. They were able to muster one graduate student with a bare minimum of broken English, but that day they were unable to locate anyone who could translate, so I never did find out what they were doing in OR.

I would advise visitors to Spain to learn Spanish. (Robert E. Machol)

PHYSICS

POSITRON ANNIHILATION AND ELECTRICAL PROPERTIES RESEARCH IN EAST ANGLIA

In early summer of 1980 I had the pleasure of visiting the University of East Anglia. This relatively new institution, established in 1965, is situated 2 miles from the center of Norwich (Norfolk) on a 270-acre site in the Yare Valley. The buildings, of modern cubic exposed-cement styling, are linked by elevated walkways. Appropriately for Norfolk, a broad (lake) has been constructed at one

corner of the campus. An additional attraction is the Sainsbury Center for the Visual Arts, a gift of the Sainsbury family which is famous in the UK for its chain of supermarkets. The center, which is in a specially constructed building near the broad, houses an art collection valued at £5 million.

On the occasion of my liaison visit I presented a colloquium. Since the physicists at the university are collocated with the mathematicians in the School of Mathematics and Physics (US equivalent of department) this was somewhat like a post-doctoral examination. I survived the experience, however, and continued on to the physics section which is relatively small (14 staff members) and in which the research interests have wisely been limited to a single unifying subject: condensed matter.

My host; Dr. R.N. West, showed me his very active positron annihilation laboratory which at first appeared to be just another corridor. Actually it is a long, air-conditioned building, 42 m × 2 m, directly abutting one of the university buildings. Housed in this laboratory are the sample chamber and the spectrometer, the latter based on two large-area gamma-ray detectors working in a coincidence mode ($\tau \sim 200$ ns). A guide-rail system allows the detectors to be moved so that the sample-detector distance can be varied continuously between 2 and 20 m. The ^{22}Na positron source and the cooled 2-circle goniometer which holds the sample are mounted between the pole faces of an electromagnet placed midway between the cameras. A third degree of freedom can be obtained by rotating both detectors simultaneously about the spectrometer axis.

Positrons emitted in the decay of the radioactive source are confined by the magnetic field until they enter the sample, where they are rapidly thermalized (10^{-15} sec) by collisions with electrons. Lifetimes of positrons in condensed matter range between 100 ps and 10 µsec. At the end of this time they annihilate with an electron, usually in a process in which two photons, each with an energy of approximately 0.51 Mev, are emitted in opposite directions from the view point of the particles (center of mass frame). Since the electron had a small transverse momentum (Pt), the 180 degree angle between the emitted photons in the center of mass reference frame is diminished approximately by the small amount (Pt/m_oc) when viewed in the laboratory reference frame. For that reason, angular correlation studies require the measurement of deviations from antiparallelism of the order of tens of milliradians.

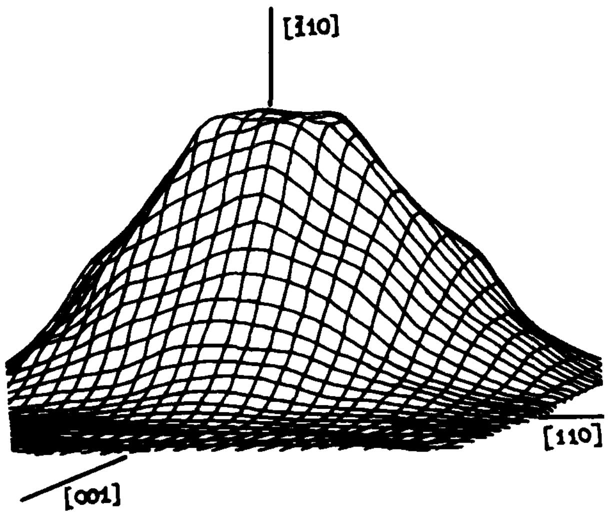
In order to perform two-dimensional studies in reasonable time it is necessary to have some form of multi-element detector system. In this unique spectrometer the detectors are Auger gamma-ray cameras originally developed for medical imaging. Each camera consists of a sodium iodide crystal with a diameter of 50 cm placed in front of a hexagonally close-packed array of 37 photon detectors. On receipt of a photon event each detector furnishes an energy, E, and two orthogonal position analog voltage levels. Each E signal is passed through a photo-peak-seeking, pulse-height discriminator that allows rejection of the bulk of the background radiation and of annihilation photons large-angle scattered in parts of the detector system other than the sodium iodide crystal. After they have been carefully matched for gain and offset, each set of position signals from each camera is combined in an appropriate analog mixer to provide a position difference signal. The resulting orthogonal difference signals are then fed into a pair of analog-to-digital computers (ADC) and thence into a PDP 1105 24 K computer. The two ADCs are controlled by output from the coincidence circuit driven by the corresponding energy circuits so that events which are valid in both timing and energy requirements are stored in a 128 × 128 channel array in the memory. Position resolution of the detectors is approximately 4.5 mm for the .511 mev radiation which results in an angular resolution of .6 × .6 milliradians when the two detectors are operated in coincidence mode with a sample detector distance of 14 m.

Typical efficiency of the machine is approximately 6 counts per second per millicurie of ^{22}Na for an aluminum test sample. The situation is less favorable for heavier metals because the photon attenuation within the sample is greater and the angular distribution is generally wider. At the time of my visit a new source had just been installed and Dr. West pointed out that with this machine it allowed two-dimensional experiments to be completed in days compared to the years required with an older machine.

Counting is usually terminated when one channel acquires 64 K counts, giving a total of well over 100 million counts. The information stored in the array is a two-dimensional electron momentum spectrum which has been obtained from the three-dimensional electron momentum distribution by integrating over one direction (z), the axis of the spectrometer. After correction has been made in the computer, for the instrumental response function the result is a two-dimensional electron momentum distribution function n(Px,Py)

of the sample. This distribution can be visualized on an oscilloscope screen or on a curve tracer either as a contour plot or as a simulated three-dimensional picture of n(Px,Py).

To date over 50 elements have been measured, and West is working on a new, detailed, review article. A previous review was published in *Advances in Physics* 22 263 (1978). The figure depicts a heretofore unpublished graph for niobium in which the vertical direction is the spectrometer axis. In the original figure every line intersection represented a data point. Here every other line has been deleted so as to enhance reproduction.



This technique does not have the resolution obtainable from measuring the De Haas-Van Alphen effect, but it has the advantage of being applicable at temperatures above that of liquid helium since it can work when the electron mean free path is relatively short. Thus it allows measurements on both sides of a phase transition and in binary alloys. West and his students have obtained results on the niobium-molybdenum system and on some rare-earth transition metal alloys.

Another unique facility is the creation of Prof. N.E. Cusack, who is studying liquid metals and metal-non metal transitions. Cusack has constructed an apparatus for measuring electrical conductivity, thermal electric power, and density at high temperatures and pressures (up to 2000 atm and up to 2000 K). The pressure vessel used in these experiments is similar in appearance to the breech end of a small artillery piece 1 m long, and 30.5 cm (12 in) in outer diameter, with a bore of 11.4 cm (4.5 in). Contained inside the pressure vessel are a furnace and the necessary particular experimental apparatus. The unused volume between the furnace and the walls of the pressure vessel is filled with pyrophyllite (which can be baked after machining) which serves as thermal insulation and limits the volume of gas. Pressure is supplied with a standard pump using Argon gas. Since the stored energy in the system may be very large in the gaseous state, it is contained in a cubic room, 2.44 m (8 ft) on a side with 5 cm thick steel walls whose military appearance is enhanced by a massive dogged door and a surplus tank prism which is used for viewing.

Cusack and his students measure the electrical conductivity and the density of a fluid conductor along an isochore (line of constant density). Conductivity is determined with a standard 4-terminal arrangment. Archimedes' principle is used to measure the relative density. The portion of the sample to be measured is contained in a vertical cylindrical cavity in an alumina insulator which also has small transverse holes. When they are filled with liquid metal, these holes act as conductors for current flow perpendicular to the cylindrical axis of this experiment. A solid sphere of different material (Nb, Mo or Mo, Ta alloy) floats in the large cylindrical space and rises or falls depending upon the relative densities. Since the sphere has a different conductivity and therefore distorts the electric field in the liquid metal, its position in relation to the current leads can be sensed by changes in the resistance. When the sphere is in the middle of the cylindrical cavity directly in line with the current leads its density and the density of the liquid are equal, and readings of temperature, pressure, and conductivity are taken. After correction has been made for the expansion of the sphere, the data give a portion of the equation of state. In an initial experiment, Cusack has measured the conductivity and density of Hg and Hg alloys containing small amounts of In or Na up to 0.2 GPa (2 Kilobar). Cusack plans to use the pressure vessel in a related set of experiments on the heat of mixing of binary alloys.

An entirely different regime of experimental conditions is utilized by Prof. D.V. Osborn and his students who have been studying phonon propagation at low temperature in solids and in liquid helium. In the helium experiments, second sound (temperature oscillation) generated by a wire heater at the bottom of a liquid helium column propagates upward to the free surface where it is partially reflected and

partially transmitted into a vapor as ordinary (first) sound. Since the first sound wave in the vapor is adiabatic, it has both a pressure amplitude and a temperature amplitude. The latter can be determined by measuring the velocity of another first sound beam which propagates perpendicular to the one generated at the surface.

The results, which are the temperature amplitudes of the first and of the second sound, are compared with theory via their ratio and involve the condensation coefficient α. This coefficient is defined for a liquid vapor interface as the fraction of those vapor atoms incident on a liquid surface which actually enter the liquid, the remainder being either specularly or diffusely reflected. Measurements of α for liquid helium help one to understand the processes by which incident atoms originate excitation in the liquid. Different models give somewhat different results since α enters differently, but in any case α appears to be somewhat less then one (.9) and independent of temperature. Osborn explains this difference as an effect arising from the creation of ripplons (surface waves) and a consequent slight change in the equilibrium liquid temperature. Full details of this experiment have just been published (*J. Physics C: Solid St. Phys.* 13 1571 [1980]). The experiment requires that the velocity of sound in the vapor be accurately known. Osborn has measured this quantity and as a by-product of the orginal experiment has determined the second virial coefficient of helium gas down to 1.28 K (*J. Physics C: Solid St. Phys.* Phys. 13 2097 [1980]).

When I concluded my tour of its facilities, I departed from the University of East Anglia with the distinct impression that in addition to the wonders of nature, art and local culture, the physics student at the university has the choice of a wide range of good research projects. (John R. Neighbours)

NMR SPECTROSCOPY IN SOLIDS, A DISCUSSION MEETING OF THE ROYAL SOCIETY

Nuclear magnetic resonance (NMR) has a history of almost 35 years, dating back to work that was done simultaneously and independently at Harvard University and the University of California, Berkeley. The Royal Society (UK) decided that 1980 would be a reasonable vantage point for a conference to assess the main accomplishments of NMR in solids over recent years and, further, to provide some sense of its future direction.

The organizers of the conference, Sir Rex Richards, F.R.S., (Oxford Univ.) and Dr. K.J. Packer (Univ. of East Anglia, Norwich) also planned that the talks and the published proceedings would present an accessible and up-to-date introduction to solids and to NMR for newcomers to the field.

The conference was held in London on 18-19 June 1980 at the home of the Royal Society, just across from St. James Park. The building is only a few blocks from Buckingham Palace where thousands, including this reviewer, had waited in a light drizzle the previous Saturday to catch a glimpse of the Royal Family on the occasion of the Queen's birthday. Certainly the prestigious location and the reputation of the Royal Society set a somewhat loftier atmosphere than that of the typical scientific gathering: the map locating the meeting place for visitors also singled out Fortnum and Mason's, an exclusive London department store, while by means of subdued lighting in the Royal Society, one could make out a framed fire bill which presented, in 8-point type, "Hints for Dealing with Fires."

Topics ranged from descriptions of nuclear-spin dynamics, upon which all solid-state high-resolution experiments are based, to chemical applications, with specimens ranging from oriented spherical single crystals to native coal. Each of the thirteen talks (by scientists from the UK, Europe. and the US) was itself a brief summary of more extensive research, and so only a few themes can be identified here.

When the dipolar broadening is removed from proton or carbon solid-state resonances, the resulting lineshape reflects the chemical-shift anistropy, a measure of how the valence electrons distort in a magnetic field. From single-crystal rotation studies, the magnitude and orientation of the chemical-shift tensor may be ascertained. Prof. U. Haeberlen (Max Planck Institüt für Medizinische Forschung, Heidelberg) was rather pessimistic about the future of such proton studies; since the bulk magnetic susceptibility screening may be comparable to the desired chemical shift, one must resort to spherical single crystals. Other resolution limitations, some of which may be further removed as discussed by Prof. P. Mansfield (Univ. of Nottingham), restrict attention to very simple crystals (which Haeberlen has virtually exhausted). Finally, there is no good theory of chemical shifts in solids to allow comparison. For carbon measurements, the limitations are less constricting,

but Dr. W.S. Veeman (Univ. of Nijmegen, Netherlands) also suggested that besides providing some interesting empirical trends, these measurements will be of more value when theory catches up.

A related area which seems more productive was discussed by Prof. R.G. Griffin (Francis Bitter Laboratory, MIT). Anistropic molecular motion partially averages the quadrupolar, dipolar, and chemical-shift tensors and, from the resulting distinctive lineshapes, he has determined the local physical orientation along the chains in lyotropic liquid crystals.

Chemical-shift anistropy is removed by spinning the sample rapidly at a 54.7° to the static magnetic field. Sufficiently fast magic-angle sample spinning (MASS) also reduces dipolar coupling, and Prof. E.R. Andrew (Univ. of Nottingham) sketched the 22-year record of MASS. When both dipolar and chemical-shift broadening is removed, the resulting simplified spectra can be used to extract chemical information. Applications were presented by Dr. J. Shaefer (Monsanto Co., St. Louis, MO) on carbon- and nitrogen-bearing polymers, by Prof. R.K. Harris (Univ. of East Anglia, Norwich) on organic polymers and crystals, and by Prof. S.J. Opella (Univ. of Pennsylvania) on proteins. Shaefer showed a particularly nice example of the power of these spin dynamics experiments in which protein synthesis was tracked in soybeans by variants of an experiment in which nuclear polarization was sequentially transferred from protons to C-13 to N-15. One recurring question in solid-state NMR asks how narrow the resonance lines can be made, and consequently, how complex a spectrum can be resolved. For C-13 resonances in amorphous organic polymers, Dr. A.N. Garroway (NRL, Washington, DC) suggested that presently achieved linewidths at low magnetic field strengths (ca 1.4T) are determined primarily by distributions of isotropic chemical shifts within the specimen, and no improvement is anticipated.

All of this solid-state technology has evolved from a clear understanding of solid-state nuclear-spin dynamics, and that field is by no means fallow, as illustrated in talks by Dr. M.E. Stoll (Sandia Labs, Albuquerque) and Prof. A. Pines (Univ. of California, Berkeley). Stoll summarized much of the pioneering work on spin dynamics and NMR of surfaces accomplished by Prof. R.W. Vaughan (California Inst. of Technol., Pasadena) who perished in the DC-10 crash at Chicago in 1979. Pines reviewed principles of heteronuclear cross-polarization, the spin dynamics technique central to all the C-13 work reported. A more active area, and one with great promise, is selective multiple-quantum spectroscopy. There, Pines explained, a small dipolar-coupled spin system is sequentially irradiated so that after irradiation it appears as if only a very-high-energy, forbidden magnetic transition had occurred and, furthermore, that the population difference was far greater than expected for thermal equilibrium. By this means an intractable dipolar spectrum is greatly simplified and presents, much more openly, a direct measure of the dipolar coupling strength. The effects of correlated molecular motion may be more easily observed.

The 2-day meeting was basically successful, although it was too brief. The difficulty in reconciling the twin goals—looking backward and looking forward in a context understandable to the nonspecialist—was apparent from the outset. Many of the speakers who had been selected to recount work completed some years ago have moved on to what, for them, are more intriguing areas. In such retrospective talks, some of the excitement was missing. Further, the presentations, only 35-minutes long, were introductory by design and so the character of the meeting was inclined more towards pedagogy; therefore it did not always convey the excitement of more technically oriented meetings. On the other hand, the strong suit of the Royal Society is to provide means for the general scientist to become well informed on a current topic; and to this extent the meeting was quite valuable.

Many speakers indicated that the more meaty topics were treated in their written contributions, which will appear about June 1981 in the Proceedings of the Royal Society (London). This written record should provide a reasonably good benchmark in the progress of solid-state NMR. (A.N. Garroway, Chemistry Division, Naval Research Laboratory, Washington, DC)

SOME SOLID STATE PHYSICS AT BIRMINGHAM

Lying near the geographical center of England is Birmingham, the second largest city in Great Britain. In early times the lack of river transport had a limiting effect on the city's development, but during the early 19th century, the construction of the extensive English canal system which crossed at Birmingham stimulated its industrial growth. At present the city is also the crossing point of the national railway system and the national highway system and is prominent in metal production, engineering and manufacturing.

The University of Birmingham, which is situated there, is a relatively new university by British standards. Its origin can be traced to a course of anatomy lectures given in a private home in 1825 by W.S. Cox, FRS, (Fellow of the Royal Society). Subsequently, Cox founded a surgical school which became Queens College in 1843 and in 1892 was absorbed into another local college named after Sir Josiah Mason, a rich industrialist. The combined schools became the University of Birmingham in 1900, and in the same year the university received a grant of 25 acres of land from the sixth Baron Calthorpe. Subsequent grants from the Calthorpe family have increased the size of the university's property to 231 acres, which it occupies on a site two miles from the center of the city.

In addition to the usual facilities, the university has an art center, which was the gift of another family. A stroll through this center, the Barber Institute of Fine Arts, enables one to view masterpieces that include a Degas, a Rembrandt, and several sculptures by Rodin.

The first professor of physics, J. H. Poynting, known for his work in electromagnetism, was appointed in 1880. Prof. W.H. Vinen, FRS, the present head of the Physics Department, told me that the university will celebrate the centenary of that event later this year. He also informed me that the Physics Department is now the sixth largest in the country, with seven professors and a staff of 150 including professionals, technicians and secretaries. One of the striking features of the Physics Department is the range of its activities: an elementary particle group which participates in experiments at The European Council For Nuclear Research (CERN); a nuclear structure group which uses a small cyclotron in polarized ion beam experiments; an applied nuclear sciences group concerned with medical applications, primarily nuclear techniques as analytical tools; an optical spectra group involved in hyperfine structure studies and their application to astrophysics problems such as the radial oscillation of the sun; a crystallography group using the Mossbauer effect applied to crystal problems; and the condensed matter group which I visited.

In the low-temperature laboratory Dr. C.M. Muirhead, Dr. E.M. Forgan, and Dr. C. Gough told me about their work. This laboratory has a tradition of heat capacity measurements; its most recent measurements on the low temperature heat capacity of neodymium (Nd) were published last year. (E.M. Forgan et al., *J. Phys. F.* 9.651 [1979]).

Neodymium crystallizes in the double hexagonal close packed (DHCP) structure in which equal numbers of atoms occupy sites with local cubic and local hexagonal surroundings. As determined by neutron diffraction, ordering of magnetic moments of the atoms occupying the different sites occurs independently to a first approximation. The moments on the hexagonal sites order at $\sim$ 20K, those on the cubic sites at $\sim$ 8K. In both cases the ordered magnetic moments lie in the base plane and are modulated in the crystallographic *b* direction in that plane.

In their latest work, Forgan and his collaborators found more peaks (4) in the low-temperature heat capacity than had been reported previously, a result they attribute to their use of a high-purity single crystal. Three of these peaks correlate fairly well with the ordering transitions observed by the neutron experiments. An 8.3K peak is the result of the ordering of cubic sites, while peaks at 7.8K and 6.0K are associated with "splitting" of the cubic and hexagonal sites respectively. Splitting here refers to the splitting of the satellites of the Bragg peaks observed in the neutron diffraction experiments and is a result of the apparent increase in spin density waves in a single region of the sample which in reality is probably due to the formation of magnetic domains. A relatively small fourth peak at 5.6K has no obvious connection with any neutron diffraction work thus far published.

This work was carried out on small samples (35mg) which necessitated construction of a sensitive calorimeter. Forgan and one of his students constructed a thermal relaxation calorimeter in which the sample is connected to its surroundings by a weak thermal link. The precision of the method is somewhat difficult to assess but they claim better than 1% agreement when the results for a standard copper specimen are fitted with an even polynomial of the eighth power in temperature. Full details had just been published when I visited. (E.M. Forgan and S. Nedjat, *Rev. Sci. Inst.* 51 55 [1980]). Forgan is continuing work with this calorimeter on the intercalated compounds NbS_2 and pyridine (C_5H_5N).

In addition to his work in science, Gough, who is a senior lecturer, has been serving as admissions officer for the Physics Department. These administrative duties have somewhat impeded his recent research. However he and Forgan have done fairly recent work on ultrasonic attenuation in niobium. (E.M. Forgan and E.E. Gough, *J. Phys. F.* 8 1073 [1978]). In this work the attenuation of longitudinal sound waves of 10-90 MHz was determined

as a function of the directly measured magnetic induction B instead of the external H field with its attendant assumptions about hysteresis in the sample being measured. Near Bc_2 their results are in reasonable agreement with the field and purity dependence predicted by microscopic theories. However, the measured dependence of attenuation on the field is not so strong as that predicted, a discrepancy between theory and experiment which is also true of the thermal conductivity and the microwave surface impedance.

A type-two superconductor such as niobium is classified as clean if the mean free path for normal electrons is long compared to the size of the flux line penetrating it near the surface. The flux lines whose diameter is given by the coherence length interact with the electrons and thus affect the ultrasonic attenuation and the thermal conductivity. Muirhead and Gough are performing a new measurement of the low temperature thermal conductivity of niobium.

A completely different field of inquiry is represented by another recent publication of Gough who is an accomplished violinist (G. Gough, *Acustica* 44, 113 [1980]). He measured the resonant response of a violin G-string and the excitation of the wolf note. In this experiment, mechanical admittance was determined by producing a known force by means of electromagnetic forces on the current-carrying string and monitoring the string response with a photo technique. The wolf note is a characteristic cyclic variation in the tone when a stringed instrument is bowed at a pitch near a strong structural resonance of the instrument. The predicted period of the note is the reciprocal of the separation of the outer two zero-crossing frequencies in the imaginary portion of the admittance curve for the coupled resonance. However, the position and separation of the zero-crossing frequencies depend critically on where the string is excited, which means that it is often difficult to excite a stable and reproducible note.

Returning to cryogenics, on a lower floor Muirhead showed me the helium dilution refrigerator he had designed and built with the aid of four technicians. In it he and M. Erickson did the work on Pr mentioned in the Rare Earth Meeting report. (*ESN* 34-7:355 [1980]). In this experiment on very pure material they do not find a Schottky type anomaly but instead the peak is depressed and has a different shape. As explained to me, a spontaneous magnetic field appears in this material below 0.1K. Then ordering with its concomitant effect on the heat capacity takes place in this field so that the process is somewhat like Van Vleck paramagnetism with exchange. The transition appears to be second order and the work is currently being written up for publication.

Also in preparation is the previously mentioned work by Forgan and Muirhead (*ESN* 34-7:355 [1980]) on the heat capacity of Nd in a magnetic field, which has several complicated antiferromagnetic phase transitions manifested as peaks in the heat capacity in the low temperature region. For the 20K transition the effect of the magnetic field applied in the *c* direction is negligible. However, if the field is applied in the *a* direction, two peaks are observed. The lower peak shifts to lower temperatures and diminishes in height as the field is increased. At 2.6T, it is quite small and occurs at ∿ 12K, and then disappears for higher fields.

Below 10K and in zero field there are four peaks as discussed above. As the field is increased in the *a* direction, the size, shape and position of these peaks change in a complicated way until at 3.2T there is only one peak (associated with the cubic site ordering) which now occurs at ∿ 8K. A field in the other basal plane direction *b* gives results qualitatively similar to a field applied in the *a* direction, while a field applied in the *c* direction has a smaller effect. Muirhead and Forgan, who have enough data to construct a magnetic phase diagram below 10°K, and hope to publish their results soon. (John R. Neighbours)

NEWS and NOTES

GAP WIDENS BETWEEN INDUSTRY AND UNIVERSITY ENGINEERING

Delegates at a recent meeting of the British Association for the Advancement of Science were told that there is a major gap that is rapidly becoming a chasm between universities and industry over the development of commercially valuable engineering research projects.

Prof. Gordon Wray, of Loughborough University's Mechanical Engineering Department, warned that in Britain worthwhile projects in engineering were not being taken up by firms because the projects had not been sufficiently developed, following initial basic research, for quick commercial exploitation.

Much of the blame for this "lies fairly and squarely on the managers of industry," he said. "Few companies will finance innovative machinery projects until they are very near to the point of success." Often this meant that promising innovations were being jettisoned all too early because of lack of financial support.

Wray maintained that academics also caused problems by quickly publishing results because research productivity was still measured in numbers of papers and books published. This meant that the rest of the industrialized world could pick up British ideas and develop them into manufactured products to compete with British firms.

The problems caused by this "pre-development" gap were only being worsened by United Kingdom grant bodies, particularly the Science Research Council, which shunned the idea of providing development costs for engineering projects. "Unless as a nation we start to appreciate the crucial importance of development, we will reach the ultimate in industrial decline when there is no money for any of the research councils to distribute," Wray added.

He urged that a clear distinction should be made between engineering and technology on one hand and science on the other, and said they should then be financed according to their relative contributions to the British economy.

According to Wray, the question that needs an urgent answer is how long Britain can afford to fund "big science" at the expense of technological innovations.

SCIENTISTS FAIL TO UNRAVEL ARIANE CRASH MYSTERY

Scientists may never find the cause of the test failure of Europe's independent test satellite launcher, Ariane, which crashed on May 23 only seconds after takeoff.

The crash was a serious blow for European scientists including Britain's university researchers, who had been relying on the rocket to form the basis of future European space research programs. As such, it would provide the launches for a variety of projects, including those to investigate Halley's comet, to plot stellar positions accurately, and to carry out X-ray astronomy work.

The rocket, which has cost Europe more than $1 billion to develop, exploded and crashed on its second test launch shortly after blastoff from the space center in Kourou, French Guiana. The wreckage was recovered, and early last month Mr. Raymond Orye, head of the European Space Agency's Ariane Program Office, said investigating scientists had now ruled out a foreign object, such as an engineer's identity bracelet, as the cause for the crash.

They were now left with three possibilities:

- Interference between launching pad and rocket motors.
- Abrupt starting sequences damaging the engines.
- Rocket motors becoming unstable when clustered together.

"In fact, Oyre added, "It could have been a combination of any of these different factors, and it may be we will never find the cause of the Ariane crash."

Measures were to be taken to counter all three possible effects, and Oyre was confident that the next test launch, in February 1981, would be successful. (The Times)

UK SCIENCE RESEARCH COUNCIL CALLS FOR REVISED PROCEDURES TO FUND UNIVERSITY RESEARCH

UK universities should take more responsibility for research and set up a $20 million fund for hopeful projects. These could then be taken up by research councils if they proved promising.

This proposal forms the basis of the Science Research Council's (SRC) evidence to the Merrison Committee which is investigating the dual-support system which is the basic mechanism for funding research in the UK.

In recent years, research councils have become concerned about the amounts

of their money used to provide basic equipment for departments—a task that should be the role of the University Grants Committee (UGC).

To combat this, the SRC has called for reallocation of UGC funds in favor of science and engineering. This could free presently frozen posts in science departments and provide $20 million in funds which would be distributed to universities which could use the money to fund unlikely and unusual research projects. Research councils are often accused of funding only work they know will produce results and of being unwilling to take risks.

The proposed scheme is considered attractive because it would necessitate only slight tinkering with budgets whereas other alternatives would require the scrapping of the whole dual-support system.

Some action will have to be taken because the research councils' budgets are so severely strained that they cannot take on the role of equipment funding that should be carried out by the UGC. Recently the SRC science board had to reject about a third of the best research proposals it received, and several Nobel Prize-winning chemists are being given less than $2,500 a year by universities to equip departments.

ONRL STAFF CHANGES

Last month we welcomed the following new staff members to ONR London: Dr. A. Paul Schaap, chemist, from Wayne State University, Detroit, Michigan; LCDR Joseph A. Strada, aerospace systems officer, from the US Navy Space Project Detachment, Los Angeles, California; and Mr. Y.S. Wu, information systems specialist, from the US Naval Research Laboratory, Washington, D.C.

OBITUARIES

George Burnett, principal and vice chancellor of Heriot-Watt University, died in Edinburgh, Scotland on September 4. He was 59.

Dr. Kurt Mendelssohn, FRS, emeritus reader in physics at the University of Oxford, died on September 18 at the age of 74. A physicist of international renown, he made important contributions to the development of low-temperature research in the UK.

It is with great sadness that we report the death of Helen Fisher on August 28 1980. Helen began her 34-year career with the US Navy in London as a secretary to the Naval Attache at the American Embassy, and came later to ONR London where she served as secretary to the Chief Scientist, as information specialist and writer-editor in the Library, and as administrative assistant in the Naval Applications Division. She will be remembered with great fondness by her many friends, and we extend our sincere condolences to her husband, Douglas.

ONR COSPONSORED CONFERENCES

Bolkesjø Workshop on Remote Measurement of Underwater Parameters, Bolkesjø Hotell, near Kongsbert, Norway, 30 October-1 November 1980.

European Visitors to the US Supported by ONR London

Visitor	Affiliation	Navy Lab./Org. to be visited
Dr. F. Durst	Sonderforschungsbereich 80 an der Universität Karlsruhe, West Germany	NRL, ONR, NOSC

ONRL REPORTS

C-2-80

A Report on the Fifth International Symposium on Nuclear Quadrupole Resonance Spectroscopy Held at the Laboratoire du Coordination du CNRS Toulouse, France—10-14 September 1979

The 5th International Symposium on Nuclear Quadrupole Resonance Spectroscopy took place in Toulouse, France, September 10-14, 1979. Seven invited lectures and a selection from more than 50 contributed papers are reviewed. The variety of topics covered illustrates the extensive potential of NQR spectroscopy in many disciplines of chemistry and physics. Applications ranging from the characterization of bacteriostatic drugs to the remote exploration for minerals are described. The number of papers reporting double resonance investigations, especially those concerned with the biologically important nuclei ^{14}N and ^{17}O, indicates that significant progress is now being achieved in this field.

C-4-80

9th International Thermal Spraying Conference The Hague, 19-23 May 1980

This is a report of the "9th International Thermal Spraying Conference," held in The Hague, Netherlands, 19-23 May 1980. Thermal spraying is a technique whereby protective coatings are formed through melting and high velocity deposition of materials onto substrates. The high temperatures for melting are achieved through combustion, electric arc, or within a plasma. The Conference, though highly technologically oriented, also focused on the scientific bases of processes and materials. The applications cited and discussed included corrosion and wear resistant coatings, erosion resistant coatings, thermal barriers, gas turbine applications, electrical applications, plastic coatings.

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